Issued December 16, 1908.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 52.

THE SUGAR BEET:

CULTURE, SEED DEVELOPMENT, MANUFACTURE, AND STATISTICS.

BY

H. W. WILEY,
Chief of the Bureau of Chemistry, and formerly Director of the Department Sugar Beet Experiment Station in Nebraska.

[Third Revised Edition, August, 1908.]

By A. HUGH BRYAN,
Sugar Laboratory, Bureau of Chemistry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., August 17, 1908.

SIR: I have the honor to transmit for your approval the third revision of Farmers' Bulletin No. 52, on the sugar beet, prepared by Mr. A. H. Bryan, chief of the sugar laboratory, who has had practical experience in the beet-sugar industry. This bulletin was last revised in 1901, having been originally issued in 1897, and first revised in 1899. Extensive changes have been made in the text that the most recent practices in sugar-beet culture might be given; references to the work of the Bureaus of Entomology and Plant Industry, bearing on diseases of the sugar beet, pests attacking it, and the development of the single-germ seed have been inserted, and the statistics have been brought up to date. It is hoped that the bulletin in its revised form may prove as useful as its predecessors to those interested in the extension of this industry, the demand for this information having continued during the past nine years.

Respectfully,

H. W. WILEY, *Chief.*

CONTENTS.

THE SUGAR BEET.

INTRODUCTION.

The successful growing of sugar beets is an art that one acquires by practice. The farmer who has made a success of raising other crops will quite often fail at first in this one, as the methods of cultivating ordinary crops do not apply in the case of sugar beets. Certain directions for the preparation of the soil, the planting, thinning, and harvesting must be followed in beet culture. Although it is possible to raise sugar beets with little regard to these directions, such a crop will usually fail to pay for itself either because the yield is too small or the sugar content of the beets too low to meet factory requirements. In commercial beet growing, therefore, carelessness leads quickly to failure, while careful regard for details spells success. Success comes at first from following the advice of successful growers, and later it may be augmented by practical experience. Certain economies can be practiced, but they should never consist in planting a smaller quantity of seed than is prescribed, nor in locating the beet field on poor land.

In the manufacture of sugar from the beet, the farmer plays an important part by supplying beets in an adequate quantity and of a high quality; but beyond that he can hardly hope to enter the field. The manufacture of beet sugar is an industry entirely distinct from agriculture, and can only be successfully accomplished by the investment of large capital and the employment of skilled artisans. From the nature of the process it is quite improbable that any simple method of home manufacture of beet sugar will ever prove commercially successful. The juice of the beet is extracted with difficulty. It contains considerable quantities of mineral salts and organic substances, which render the crude sugar and molasses therefrom unpalatable. Simple processes for the extraction of the juice can at best remove only 60 to 70 per cent of the sugar which the beet contains, and thus a percentage of loss is incurred which at the very outset renders it impossible for a home apparatus to compete with a large factory. Beet sugar, for the reasons given above, can not be used in the raw state, as is the case with the products derived from the sugar cane, sorghum, and the maple tree. The refining of the sugar requires a heavy outlay for machinery and a high degree of supervisory skill. It can not, therefore, be accomplished upon the farm.

The beet-sugar industry offers a great opportunity for the profitable extension and diversification of agricultural industries in this country. The sugar beet is proving a profitable crop for the farmers not only in old settled areas where it must compete with a large list of established crops, but in the newly developed regions of the West where its adaption to intensive farming makes it a favorite crop for culture under irrigation. Its influence in developing stock breeding, feeding, and dairy industries is attracting the favorable attention of farmers interested in these pursuits. The rapid extension of the industry during the past few years shows that its value is gaining recognition; and there appears to be no valid reason why this extension should not continue until all the sugar consumed in the United States is made from crops grown by American farmers.

TEMPERATURE CONDITIONS AFFECTING THE BEET-SUGAR INDUSTRY.

Experience has shown that the sugar beet reaches its highest development in north temperate latitudes. So far as the production of beets with high tonnage is concerned, it is found that this can be accomplished far to the south, but beets grown there are, on the whole, less rich in sugar and less suitable for the manufacture of sugar than those grown farther north. It must be remembered, however, that the expressions north and south do not refer to any absolute parallels of latitude, but rather to isothermal lines, which in many cases vary widely from the parallels of latitude and in some cases cross them almost at right angles.

Theoretical beet-sugar belt.—As a result of many years of careful experimentation, it may be said that as far as temperature alone is concerned the sugar beet attains its greatest perfection in a zone of varying width through the center of which passes the isothermal line of 70° F. for the months of June, July, and August. This zone for this country is shown in the accompanying map (fig. 1).

This isothermal line, for the United States, begins near the city of New York and passes up the Hudson River to Albany; thence turning westward, it runs near Syracuse and passes in a southwesterly direction, touching the shore of Lake Erie near Sandusky, Ohio; turning thence in a northwesterly direction, it enters Michigan and reaches its highest point in that State near Lansing; then going in a southwesterly direction, it enters the State of Indiana near South Bend, passes through Michigan City, then in a northwesterly course continues through the cities of Chicago and Madison, reaching its highest point near St. Paul, Minn.; thence it extends in a southwesterly direction until it enters the State of South Dakota, where it turns again northwest and reaches its highest point in Dakota just above the forty-fifth parallel of latitude, where it crosses the Missouri River. The iso-

thermal line then turns almost due south, following very closely the one hundred and first degree of longitude until it leaves the State of

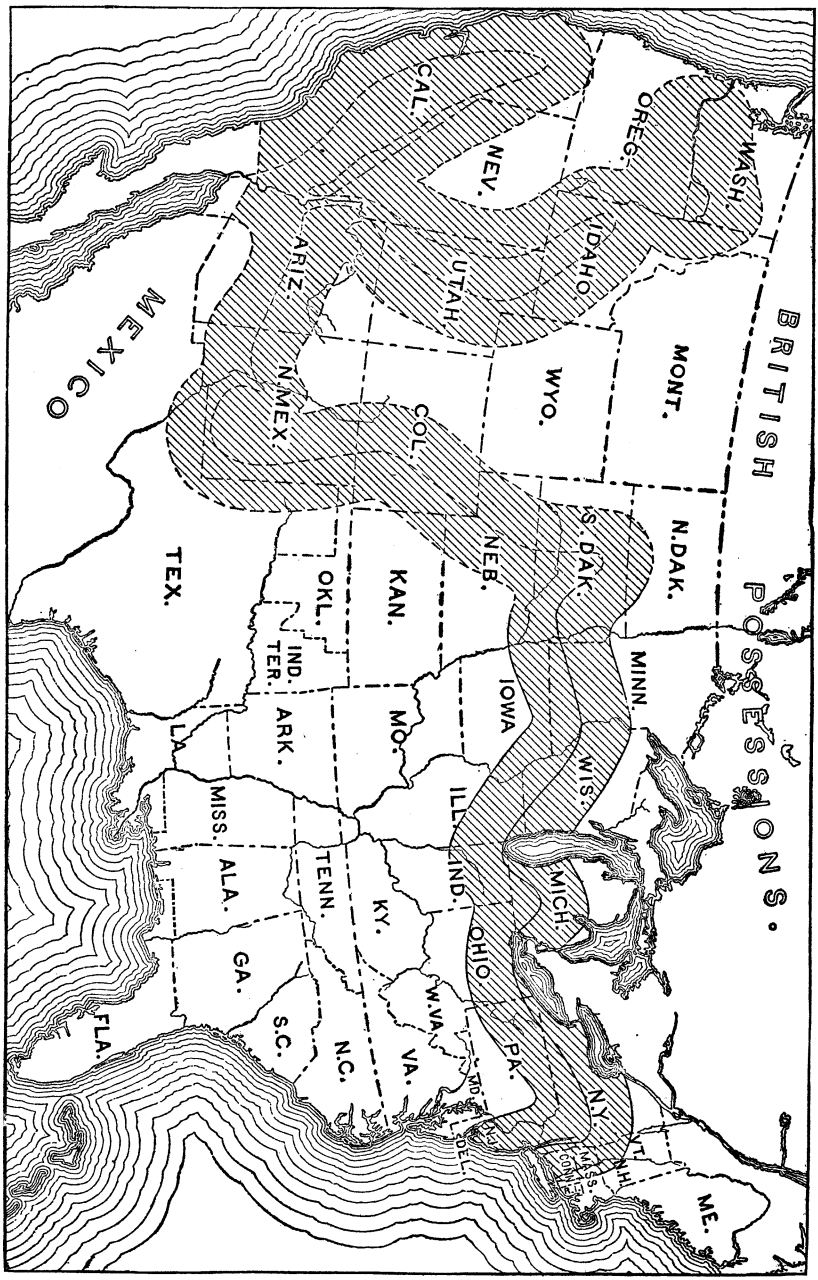

FIG. 1.—Temperature zone in which the sugar beet attains its greatest perfection.

Nebraska near the northeast corner of Colorado; passing in a southwesterly direction through Colorado, it reaches, at Pueblo, almost to

the one hundred and fifth degree of west longitude, whence it passes in a slightly southeasterly direction into New Mexico, turns to the west, and crosses the one hundred and fifth degree of longitude at about the thirty-second degree of latitude. Then turning westward, it passes in a very irregular line through the States of California, Oregon, and Washington.

Extending a distance of 100 miles on each side of this isothermal line is a belt which may be regarded as the theoretical beet-sugar area of the United States. There are doubtless many localities lying outside of this belt, both north and south, in which the sugar beet will be found to thrive; but this will be due to some exceptional qualities of the climate or soil and not to any favorable influence of a higher or lower temperature. A study of the location of the sugar factories operating to-day will show that only five factories are outside of these lines. A mean temperature of 70° F. in the summer, however, must not be regarded as the only element of temperature which is to be taken into consideration. In those localities where the winters come early and are of unusual severity will be found greater difficulties in the production of sugar from the sugar beet than in localities where the winters are light and mild, although the mean summer temperature of both localities may be represented by 70° F.

MOISTURE CONDITIONS AFFECTING THE BEET-SUGAR INDUSTRY.

Although conditions of temperature must be taken into consideration in selecting sites for beet-sugar factories, those of rainfall must also be studied. The sugar beet requires a certain amount of moisture in order to produce its normal crop. This moisture must be derived either from precipitation in the usual way or from irrigation; or else the soil must be of that particular quality which will allow subterranean moisture to reach the rootlets of the plants. Soil of this kind appears to exist in many localities in California, where beets are grown almost without rain. The porous and sandy soils adjacent to many of the Western rivers, such as the Arkansas River in eastern Colorado and western Kansas, also appear to furnish a sufficient amount of subterranean moisture to produce a good crop in connection with the rainfall, of which, however, but little is expected in those localities during the summer months. Where there is little subterranean moisture, and where irrigation is not practicable, the culture of the sugar beet should not be undertaken unless an average summer precipitation of 2 to 4 inches per month can be depended on. There are many conditions of agriculture, however, under which the beet becomes quite independent of extremes of precipitation. The beet may thrive with very little rainfall or with a great deal, if properly cultivated in a suitable soil.

GROWING BEETS ON IRRIGATED LANDS.

The experience of more than twenty years in California and eight years in Colorado has shown that the climatic data, regarded as of prime importance in beet culture in Europe, can not be regarded as rigidly applicable to this country. The successful growth of sugar beets in the arid regions of our country, with irrigation, has introduced a new factor into the science of beet meteorology. While the arid area on which beets can be grown without irrigation is probably confined almost exclusively to the coast valleys of California, the successful commercial production of sugar beets in Utah and Colorado has opened a new and extensive field. What has taken place in these States is being rapidly duplicated in Idaho; a beginning has been made in Montana, and the time is undoubtedly coming when beets will be grown in Wyoming and probably throughout the whole arid region.

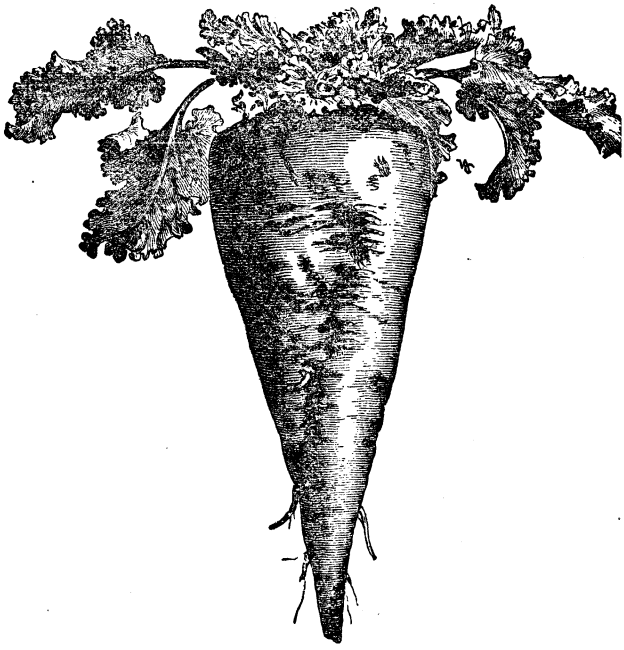

FIG. 2.—Kleinwanzlebener sugar beet.

The northern parts of our Eastern and Middle States and the States of Oregon and Washington have at least an equal chance for the successful production of beet sugar with the fields of Germany and France. The irrigable parts of the great Southwest have advantages of soil and climate which will enable them to enter into competition in the production of beet sugar. To be able to control the moisture of the soil is a matter of prime importance to the beet grower. In the arid region the time at which the beet matures can be controlled by withholding the water. Furthermore, there is no danger of loss due to second growth, so easily induced by late warm autumnal rains.

The high cost of good irrigation renders it imperative that the areas under culture be devoted to a crop which is capable of producing a

more valuable yield than is afforded by cereal culture. In a dry soil the beet can endure without damage a low temperature, which would prove quite disastrous in a wet climate. More complete maturity may be thus obtained, and a more leisurely harvest. In fact, there is no staple crop which can compete with the sugar beet in demanding the favorable attention of those interested in irrigation. If a net profit of from $10 to $20 per acre can be secured, from $100 to $200 per acre can be paid for the land. It is estimated that nearly 80,000,000 acres of land in the arid regions of the United States may eventually be irrigated, being nearly one-fifth of the total area. Of this area perhaps 10 per cent is capable of easy and speedy irrigation. One million acres planted to beets would yield, under intensive culture, a quantity of sugar sufficient, with the Louisiana product, for domestic consumption. There is nowhere in sight a more promising prospect for agricultural development than in the production of sugar beets on irrigated lands.

VARIETIES OF BEETS.

Botanically all kinds of sugar beets are of the same species as the common garden beet (*Beta vulgaris*). The differences between varieties have arisen from selection and breeding. Certain valuable peculiarities resulting from natural variations or mutations have, through careful selection, been *fixed*, and pure strains having these superior qualities associated with certain distinguishing external characters have been developed.

The shape and size of the beet, its color, the character of the foliage, whether erect or spreading, etc., are the most frequent marks of distinction. The beets are also frequently designated by the names of those who have developed them, or by the name of the town or locality in which they have been grown.

Among the more frequently occurring varieties grown in Europe may be mentioned the Improved Kleinwanzlebener, the Kleinwanzlebener, and the Vilmorin, the two latter being most widely known in this country. Sugar manufacturers prefer those varieties which yield a high percentage of sugar, since the juices are purer and the expenses of manufacture and the cost of the raw material are less. Large beets yielding a large tonnage were usually grown in Europe prior to the adoption of legislation placing a tax on the beet itself instead of on the sugar, and were preferred on account of the value of the pulp for cattle feeding.

The certainty that the seed has been grown according to the most scientific methods is of great importance to the beet grower and sugar manufacturer, since the former may depend upon producing rich beets and receiving fair compensation for his labor and the latter is enabled to operate his factory economically. The beet has reached

such a high state of perfection as to make the least degree of laxity in its treatment exceedingly dangerous to its qualities.

The best beet for general cultivation is probably the Kleinwanzlebener, which seems now to have a wider cultivation in this country than any other variety. The general character of this beet is shown by figure 2. It has a conical root, straight and even, quite large at the head and rapidly tapering, and is distinguished from the Improved Vilmorin by its brighter color and its lighter-colored leaves, which are beautifully undulating or scalloped about the edges. Coming from a cross in which the Improved Vilmorin entered largely, the Kleinwanzlebener is to-day a fixed variety and is equally well produced in France and Germany. It succeeds in soil of an alluvial nature and average richness and on level plateaus. In soils very rich in humus it ripens poorly and loses much of its richness. Like the Improved Vilmorin, toward the end of the growing season its leaves are completely spread. Under those conditions of culture where the Improved Vilmorin gives from 12 to 16 tons per acre, the Kleinwanzlebener gives from 14 to 18 tons; and from these beets 13 to 18 per cent of sugar can be obtained.

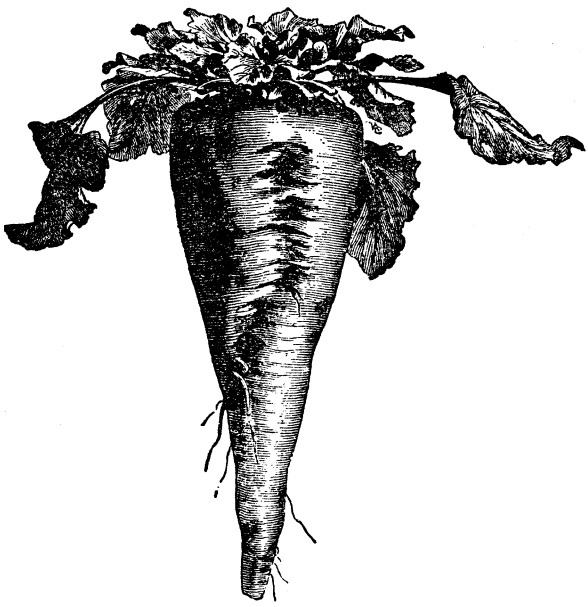

FIG. 3.—White Improved Vilmorin sugar beet.

The other general type, the Vilmorin, is illustrated in figure 3. This beet is the result of thirty-five years of methodic and persevering selection based upon the lines to be indicated hereafter. In regard to its preservation, it is recognized that it holds its sugar content as well as any other variety. In those factories in Germany and France in which sugar is manufactured from the Improved Vilmorin in connection with other varieties it is the custom to reserve this variety for the end of the season and to work up the less reliable beets at an earlier date. It is also said to resist better than any other

variety the unfavorable influence of certain characters of soil and of certain manures. In black soils, rich in organic matter, it gives great results, while most other varieties of beets become watery or saline in excess. Excessive quantities of nitrogenous fertilizers, which are carefully excluded from ordinary varieties, can be applied with safety to the Improved Vilmorin; a great number of experiments have shown that this can be done without serious deterioration in the quality of the beet and with a considerable increase in weight. However, experiments with Kleinwanzlebener beets show that they are also susceptible to the influence of such fertilizers, as is shown by a gain in tonnage when fertilized. From thousands of analyses it has been established that about 16 per cent of sugar can be obtained with the Vilmorin and that under favorable conditions from 12 to 16 tons per acre can be raised.

In this country considerable quantities of beet seed have been grown at Fairfield, Wash., and also by the Utah-Idaho Sugar Company in Utah and Idaho chiefly, in the latter case, for its own use. In California and Michigan also some seed is produced.

Within the last four years the Department of Agriculture has been doing considerable work in endeavoring to develop a strain of beets bearing single-germ seed balls (see p. 30) and in growing seed better adapted to the requirements of this country. Considerable progress has been made along these lines. The farmer growing beets for a factory does not have to consider these points to any great extent, as the factories buy the seed and then furnish it to their growers. It is of prime importance that the factory purchase the best seed, and they are better able to judge as to the kind of seed desired and to test its vitality.

CULTURE OF SUGAR BEETS.

Farmers who raise beets for a sugar factory are not left entirely to their own resources in growing the crop. They enter into a contract with the factory management which outlines the methods to be employed. Then the factory employs an agricultural superintendent and a corps of assistants whose duty it is to go among the growers giving instructions and suggestions regarding the selection and preparation of the soil, planting, cultivation, time of harvesting, etc. These men are of course well informed on all phases of beet culture, and they are usually able to make valuable suggestions in regard to the cultivation of other crops grown in rotation with beets. Their instructions and influence, therefore, tend to improve the farm practice of communities in which sugar beets are grown.

SELECTION OF SOIL.

The sugar beet does not require a particular kind of soil for its proper production. In general, soils are described for practical purposes as clayey, sandy, loamy, or alluvial soils; all of these soils will produce beets. The black prairie soils also have been found, with proper cultivation, to produce excellent beets. Perhaps the best soil may be described as a sandy loam, a soil in which there is a happy equilibrium of organic matter, clay, and sand.

New land should not be selected to grow sugar beets, for the crop is not a good reclaimer of soils; and especially to be avoided is new land containing decaying vegetable matter, which produces only rank growth with low sugar content. Preferably the most productive land on the farm should be used, such a soil as will yield a good crop of Indian corn, wheat, or potatoes. The soil should neither be so compact as to interfere with cultivation to a depth of 10 or 12 inches nor have a tendency to bake hard. It may contain some alkali, as sugar beets are not especially susceptible to injury from this constituent. The soil should be reasonably level, but it should also be well drained. Natural drainage on level soil being somewhat deficient, tile drainage may be practiced with advantage.

FERTILIZATION.

Happily, in most American soils there is still sufficient natural fertility to produce a good crop of sugar beets; whereas in the soils of Europe, where sugar beets have been grown for years, the farmers must depend on fertilizers to insure a remunerative crop.

The principles of fertilization depend upon the fact that a soil should have returned to it all that the harvest has removed, and an unproductive soil be supplied with those elements in which it is deficient.

The soil ingredients most essential for the successful production of sugar beets are nitrogen, phosphoric acid, potash, and lime.

The following are the quantities of these constituents in 1,000 pounds of beet roots and in an equal quantity of beet leaves, as determined by numerous analyses:

Constituents.	In 1,000 pounds of roots.	In 1,000 pounds of leaves.
	Pounds.	*Pounds.*
Potash	3.3	6.5
Phosphoric acid	0.8	1.3
Nitrogen	1.6	3.9
Total ash	7.1	18.1

It will be seen from the foregoing table that, for equal weights, the leaves make a heavier drain on the plant-food elements of the

soil than do the roots. The disposition to be made of the leaves is therefore a matter of considerable importance. By leaving them on the land the plant-food elements which they contain will be returned to the soil. If they are removed for feeding, the need for applications of commercial fertilizers is increased. The leaves may, however, be fed and the resulting manure may be returned to the soil without material loss of these fertilizing constituents; or in some cases stock may be turned into the beet fields to feed on the tops and leaves remaining on the ground after the harvest is completed.

Most soils contain a sufficient quantity of lime, although there are some in which the supply of lime is naturally deficient; and such soils would be benefited by an application of land plaster, burned lime, phosphatic slags, or ground shells. Phosphoric acid and potash are supplied in the form of ordinary commercial fertilizers—the phosphorus as ground bone, superphosphate, or basic slag, and the potash may be supplied in the form of muriate or sulphate of potash or as kainit.

Nitrogen may be supplied in the form in which it exists in ground bone, or from the refuse of the slaughterhouses in the form of dried blood and tankage, or as cotton-seed meal or oil cake, or as nitrate of soda, sulphate of ammonia, etc.

Barnyard manure offers a ready means for fertilizing the soil, and one which every farmer can employ. By its use, humus is added to the soil as well as small percentages of potash, phosphoric acid, and nitrogen. There is a great difference of opinion as to the best time and method for applying it to beet land. In general, however, it should be applied, in a well-rotted condition, in the autumn before the ground is plowed. The quantity per acre depends, of course, on the fertility of the soil; but in any case it is not best to apply a very heavy dressing. With poor soils it is best to apply the manure for several years in succession, rather than to apply enough at once to bring it up to the required state of fertility. Too copious an application of manure is apt to produce overgrowth in the beets, which makes them ill suited to the manufacture of sugar. If the manure be applied in an unrotted condition it is apt to seriously injure the crop in case of dry weather.

As to the relation which the quantity of material returned to the soil should bear to the quantity abstracted by the beet, it may be said in general that it is desirable to return as much nitrogen, from one and a quarter to one and a half times as much potash, and two and a half times as much phosphoric acid as have been removed by the roots. Greater additions of potash and phosphoric acid have no disadvantageous effects upon the crop. But it must not be expected, on the other hand, that increasing fertilization, especially

with potash, will produce proportionately increasing crops, as has been asserted by some.

As regards the use of nitrate of soda for fertilization, if applied late to the beet crop, it prevents its ripening, thereby lowering the sugar content. It is best applied early and in small quantities. Heavy applications are thought to injure the beet for manufacturing purposes.

CROP ROTATION.

Every farmer should understand that he can not continuously grow any crop on the same ground and secure maximum results. Many try to do this, but they do it to their own loss and the depletion of the soil.

One of the great objects of crop rotation is to bring about and maintain an equilibrium of soil constituents and conditions. The best rotation is the one in which the method of culture and action of the plant each year leave the soil in the best condition for the following crop. Beets do best after alfalfa, corn, or small grains.

A good scheme of rotation is, first, wheat; then beets; then clover for two years, the last crop being plowed under; then potatoes, wheat, and beets in the order mentioned. If alfalfa can be grown, it should be included in the rotation of crops. Also in some sections potatoes do well in the rotation. By this method, and a judicious use of stable manure and commercial fertilizers, the fertility of the soil can be maintained and even increased. Beets do well after small grain crops, because these, being harvested early, leave the ground ready for late autumn plowing, an important point in successful beet culture.

PREPARATION OF THE LAND FOR PLANTING.

The field in which beets are to be planted should be selected and plowed in the late autumn to the depth of at least 9 inches. As a rule the plow in each furrow should be followed by a subsoiler, which will loosen the soil to the depth of 6 or 7 inches more. A convenient subsoil plow is shown in figure 4. Each field to be planted in beets should thus have the soil prepared by thoroughly loosening it to the depth of from 15 to 18 inches. The land, being exposed through the winter, becomes quite mellowed, and in the spring can in many cases be prepared for planting by thoroughly cultivating the surface of the soil until it is reduced to perfect tilth. The large cultivator shown in figure 5 can be conveniently used for this purpose, followed when necessary by a harrow and roller. Too much can not be said of the importance of correct preparation of the ground before seeding, as on this condition the crop depends to a large extent. The seed bed should be uniformly well pulverized. It is desirable, however, that

each portion of the field to be planted should be thoroughly prepared immediately before the planting takes place. For instance, if the planting is to be made on a given day, the soil should be thoroughly

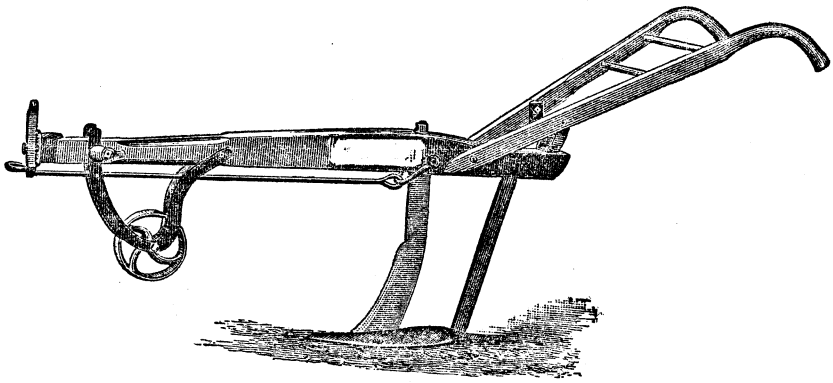

FIG. 4.—Subsoil plow.

prepared on the previous day. Thus all weeds and grasses which have started to grow are killed, and the beets have an even chance with the weeds for growth. If, on the other hand, the soil be prepared a week or even a few days before planting, the weeds and

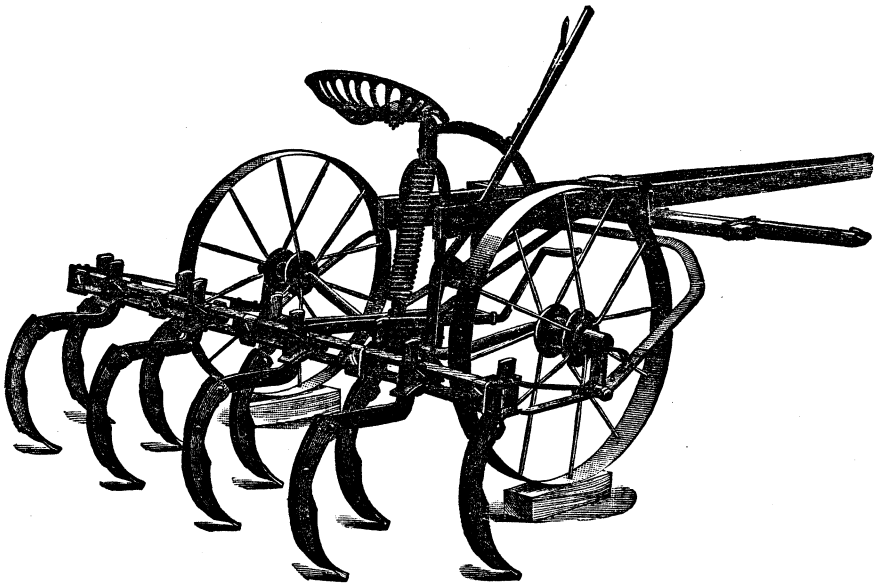

FIG. 5.—Cultivator for sugar beets.

grasses get a good start, and it is difficult to free the beets therefrom. In case the ground has to stand any time before seeding after being prepared, it should be constantly and thoroughly cultivated.

PLANTING THE SEED.

Hand planting of the seed may be practiced when a very small plat is to be put in beets, but where a field embracing an acre or more is to be planted it is not convenient. In such cases planting by drill is best. Almost any garden drill can be adapted to use with beet seed. Special drills for sugar-beet seed are made by many manufacturers of agricultural implements. In planting by drill it is necessary to use from 15 to 20 pounds of seed per acre; in planting by hand from 10 to 15 pounds will be found sufficient.

A very convenient hand drill, which is especially fitted with a beet-seed dropping apparatus, is shown in figure 6. This machine marks the row, excavates the furrow, drops the seed at any required distance, and covers it.

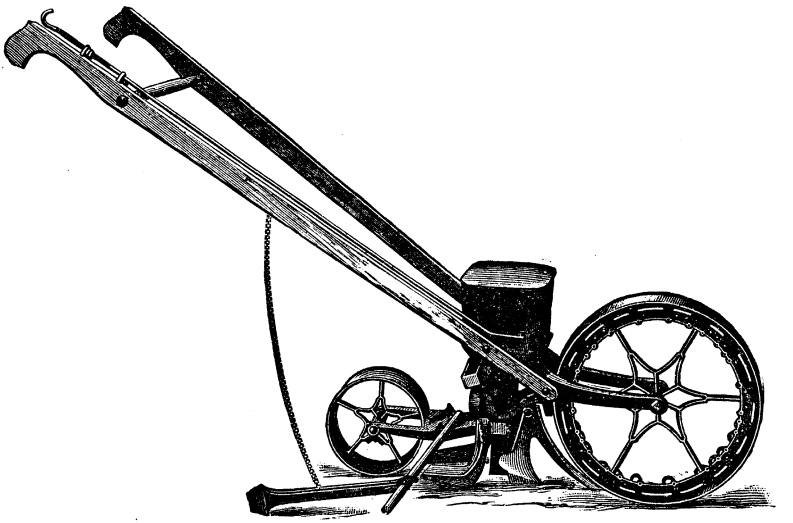

FIG. 6.—Hand seed drill.

The beets should be covered to a depth of one-half inch to 2 inches, according to the state of the soil. If the soil be moist and in excellent condition, the beet seed should not be covered more than half an inch. If, on the other hand, the soil be very dry and early rains are not probable, the seed should be covered to a depth of 2 inches.

In the matter of space between rows there is considerable variation. In some cases the rows are made only 16 inches apart, and in others as wide as 28 inches. In recent years the tendency has been to increase rather than diminish the distance, though much depends on the soil and local conditions. It is argued by many that the greater ease and economy of culture with the wider rows outweigh the increased yields per acre which may be secured in the narrower rows.

When a considerable acreage is planted, it is important to be able to plant two or more rows at a time. The accompanying illustration (fig. 7) shows a seed drill which plants four rows at once.

In planting by hand or by drills an effort should be made to drop the seeds singly and at equal distances apart.

Under irrigation planting can be accomplished at almost any time, as the ground can be irrigated, then cultivated, and the seed planted at once.

Beets should be planted as early in the spring as practicable, but the ground should have sufficient moisture and warmth to cause germination of the seed. Experience has shown that the early-planted beets almost uniformly produce a larger yield with a higher content of sugar than the late-planted. No exact date can be fixed which would be suitable to all localities. In most of the localities in

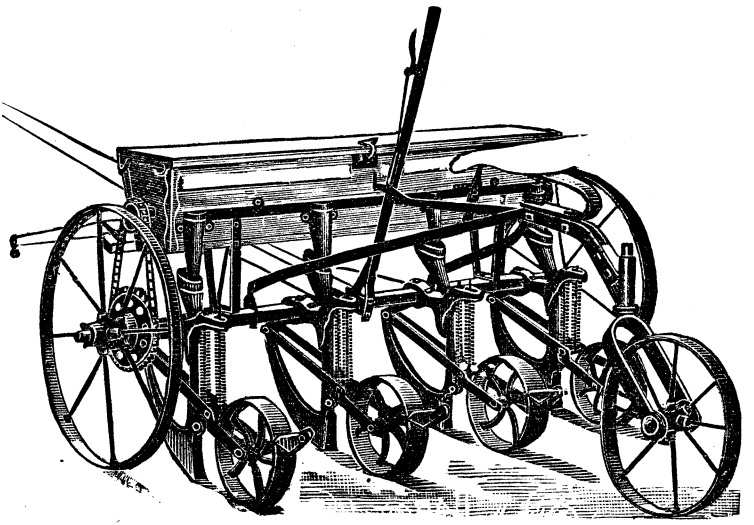

FIG. 7.—Four-row seeder.

the beet area or the United States it will not be found practicable to plant earlier than the first week in May. In exceptional seasons a part of the sowing can be accomplished in April. On the Pacific coast, especially in central and southern California, the sowing can take place at a much earlier date. In parts of California planting is done in December with favorable results. But if planted too early, some of the beets will go to seed before harvest time. When this happens the percentage of sugar is diminished.

Most factories, by way of inducement to early planting, offer free seed for replanting any beet fields that may be injured by frost or other unfavorable conditions. This early planting makes it possible for the factory to begin its campaign earlier in the fall.

CULTIVATION.

To prevent the formation of a crust, and to keep the weeds and grass from getting a start, it is often necessary to cultivate the beet field with a spike harrow before the plants come up and to continue such cultivation until the beets are large enough for row cultivation to begin. Cultivation must not be postponed or neglected unless wet ground makes it impossible. The purpose of cultivation is two-

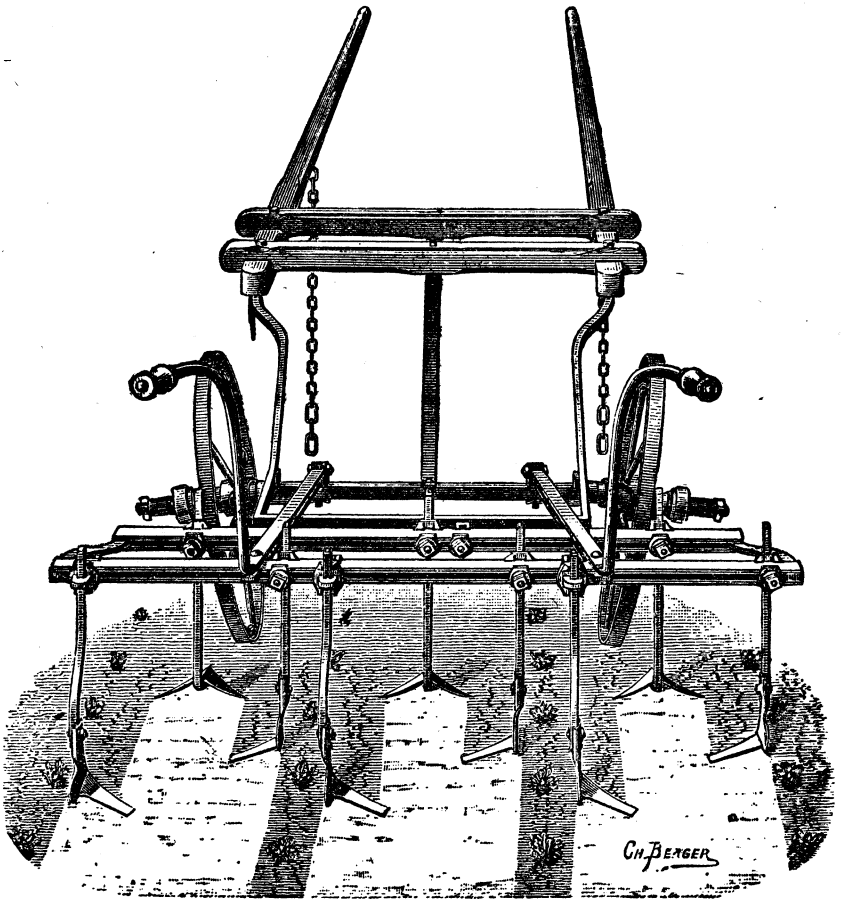

FIG. 8.—Horse hoe.

fold: (1) To hold the moisture in the soil; (2) to destroy the weeds and grass, as in the early stages of the beet's growth these can spoil the stand by choking the plants. When the land becomes dry is the most important time for cultivation in order to prevent the escape of moisture from the soil. Cultivation should be continued until the beets have attained such a size that the leaves cover the ground.

When large fields are cultivated, the horse hoe, a model of which is shown in figure 8, may be used. For smaller fields a similar apparatus propelled by hand may be employed. Convenient implements of

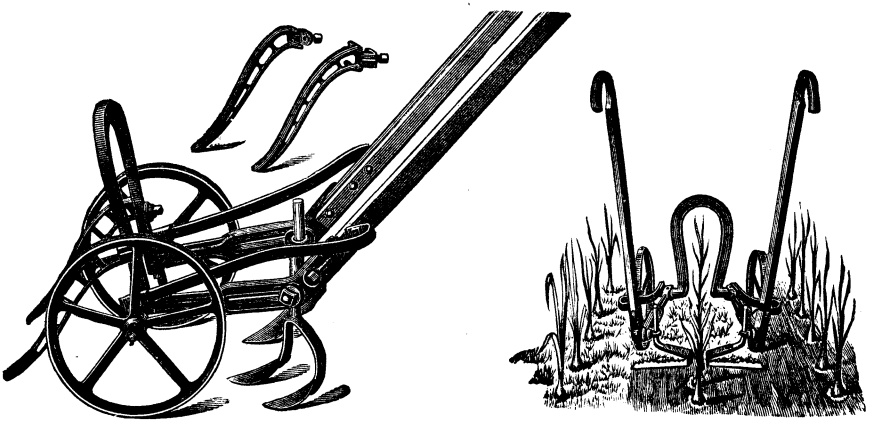

FIG. 9.—Hand-wheel hoes.

this kind are shown in figures 9 and 10. This implement frees the spaces between the rows of beets from weeds, and guards are used to prevent the growing beets from being covered by the loose soil.

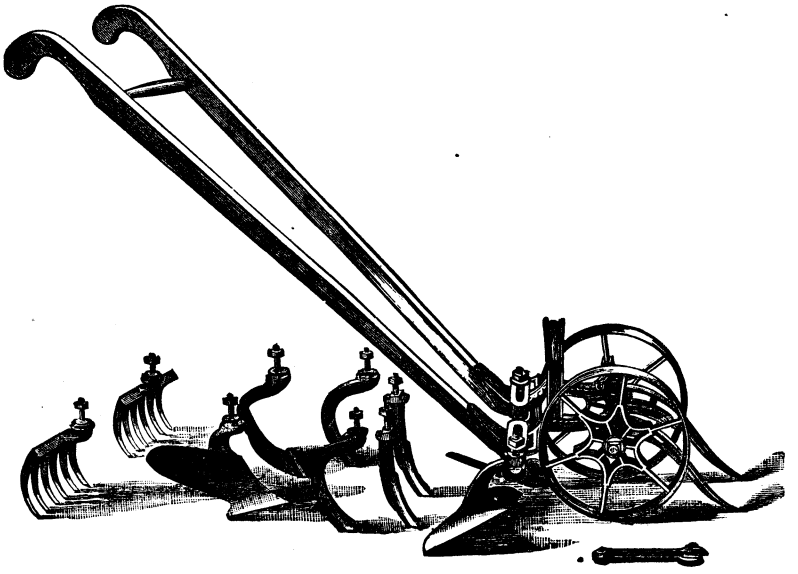

FIG. 10.—Cultivator for beets.

In growing beets with irrigation a cultivator which will prepare the furrow for conducting the water over the field is important. Such a device is shown in figure 11. In this implement the plow shown in the

rear of the cultivator teeth forms the required furrow and can be set at any required depth.

In the cultivation of large areas an implement adapted to four rows of beets is desirable. Such an implement, however, can not be

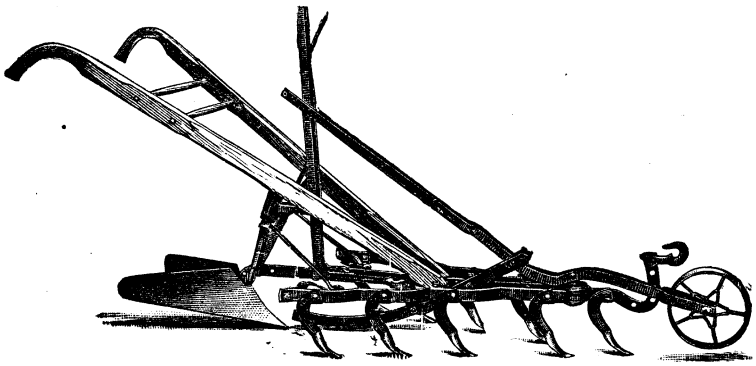

FIG. 11.—Beet cultivator for irrigated lands.

advantageously used, except in those cases where the beets have been sown with an implement planting four rows at a time. The cultivator shown in figure 12 is suitable for use on fields which have been planted

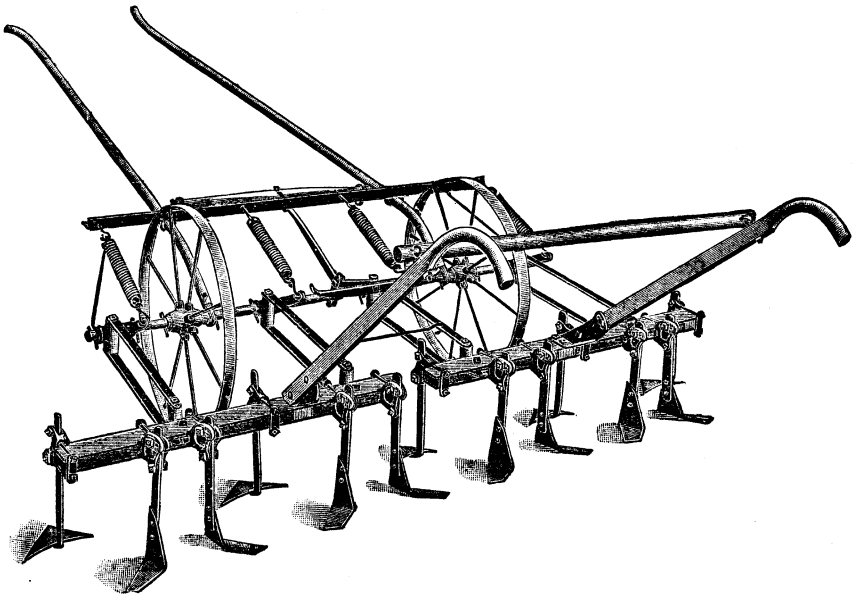

FIG. 12.—Four-row beet cultivator.

with the seeder shown in figure 7. Different kinds of devices for cultivation can be easily attached so that the implement can be used as a plow, a cultivator, or a harrow.

BUNCHING AND THINNING.

When the beets show three or four leaves, they should be bunched and thinned. The bunching is best accomplished with a short-handled hoe. One stroke of this implement takes out all the beets in the row except small bunches from 8 to 10 inches apart, depending on the width between the rows and other circumstances. From these bunches should be removed by hand all the plants but one, the largest and healthiest. Great care should be exercised in this work, and by careful selection all of the inferior plants will be removed. On the proper thinning, the tonnage largely depends. This does not mean that less space should be left between the plants. If the rows be 18 to 24 inches apart, the space between plants can vary from 8 to 10 inches, depending on the nature of the soil. When thinning, it is a good plan to give the ground a thorough hand hoeing. This can be done at a little extra expense and will pay for itself in the long run. If the thinning is put off too long, the crop will suffer.

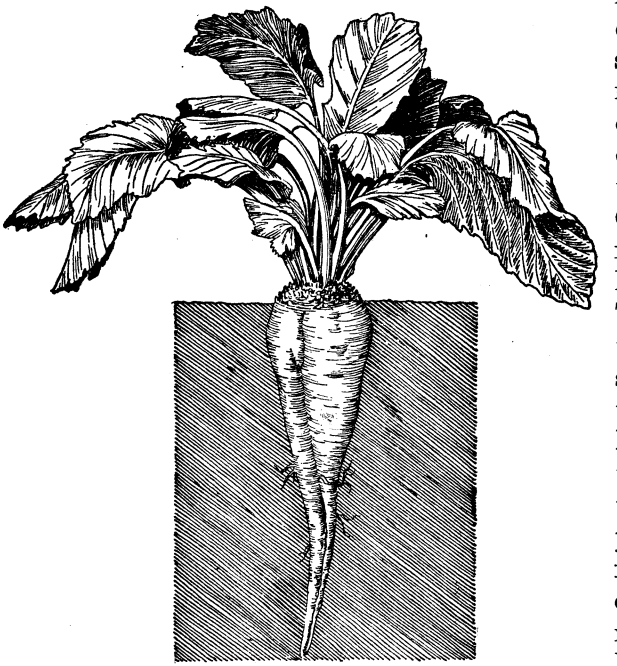

FIG. 13.—Correct position of a mature beet in the soil.

POSITION OF THE BEET IN THE SOIL.

It is important not only that a sugar beet should be of proper size and shape, but also that it be grown in such a manner as to secure the protection of the soil for all of its parts except the top with foliage. The proper position for a beet to occupy in the soil at the end of growth is shown in figure 13. This position can only be secured for the beet by growing it in a soil sufficiently pervious to permit of penetration by the taproot to a great depth. It is for this reason that subsoiling in the preparation of a field for the growth of sugar beets is of such great importance. If the beet, in its growth, should meet a practically

impervious subsoil at the depth of 8 or 10 inches, the taproot will be deflected from its natural course, lateral roots will be developed, the beet will become disfigured and distorted in shape, and the upper portion of it will be pushed out of the ground. Experience has shown that the content of sugar in that portion of a beet which is pushed above the soil is very greatly diminished.

HARVESTING AND DELIVERY OF BEETS.

The time for harvesting varies in different localities. In southern California the beets planted in December are ready for harvesting in the latter part of June or the first of July. In general it may be said that beets planted the first week in May will be ready for harvesting

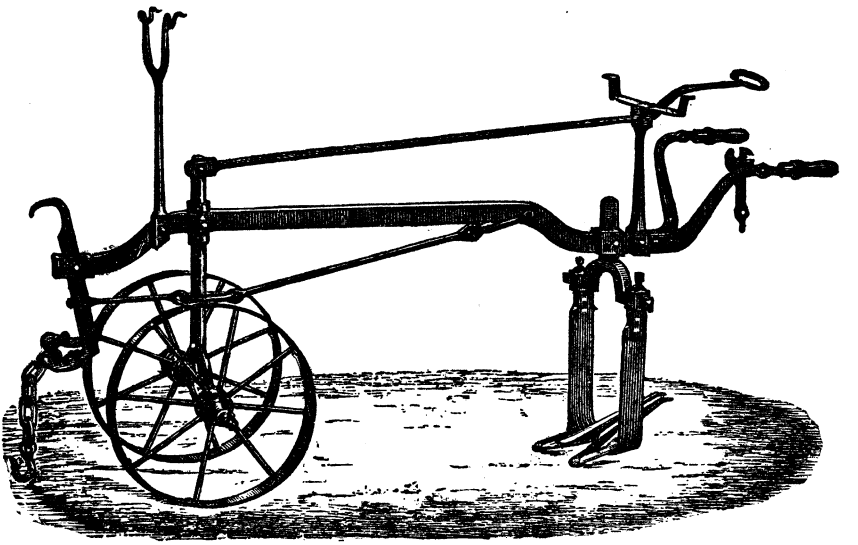

FIG. 14.—One type of beet harvester.

about the 1st of October. Harvesting should be postponed to as late a date as possible, provided the beets are in no danger of a second growth and are not exposed to a freezing temperature. The leaves of the ripened beet change from a rich to a yellowish green, droop and lie close to the earth, and many of them die.

REMOVING BEETS FROM THE GROUND.

The harvesting is easily accomplished by first loosening the beets in the soil and then removing them by hand. For loosening the beets a common turning plow is often used. The edge of the share cuts off the tap roots at the proper depth and the beets are lifted and thrown over by the moldboard. Better adapted to this work, however, are plows which have been specially constructed for beet harvesting. In many localities beets are harvested with an implement such as that

shown in figure 14. It can be used very successfully where rows are perfectly straight and the beets of uniform size. The lifting part of the apparatus runs deep enough in the soil to catch the beet below its middle part. As the "digger" is drawn forward, the beets are caught between its two prongs, which are nearer together in the rear and slope upward; as a result the beets are lifted and the tap roots broken. After the harvester has passed, the beets are lifted out of the ground by means of the leaves.

Several more or less complicated devices have been invented which are designed not only to lift the beets but to cut off the tops and shake off the adhering dirt. Some ambitious inventors have attempted the construction of a harvester which will not only dig, top, and clean the beets, but load them into a wagon. Such a harvester is much to be desired; but while some of these inventions have worked fairly well under favorable conditions, it must be said that none has yet proved satisfactory under all conditions. Hence the use of such harvesters has been very limited.

TOPPING.

The next operation consists in removing from each beet the top or neck bearing the leaves. This is done by a large knife. The object of removing this portion of the beet is to prevent the mineral salts, which have accumulated in large quantities therein, from entering the factory, as they exercise a very deleterious influence on the crystallization of the sugar. The tops and leaves are well fitted for feed or for fertilizing purposes. (See p. 39.)

The removal of the tops of the beets is a tedious process, which in Europe is performed by women and children. In this country sometimes the whole family goes to the beet field and performs the work. More commonly, however, it is done by laborers of various nationalities, who are brought in by the factory and with whom the farmer contracts to do this work as well as the hand work of growing the crop.

The topping of the beets can be a source of great waste for the farmer, as too much may be taken off and the tonnage decreased. Constant supervision is necessary in this work. Several attempts have been made to construct a mechanical device by which the beets can be topped, thus saving a large expense, and perhaps a successful device of this kind may some day be invented. So far as is known at the present time, however, this process has not been successfully accomplished by machinery, and the topping must still be done by hand.

When the beets are topped they are thrown into piles, and the leaves are thrown over them as a protection from the sun or frost until they can be delivered to the factory.

DELIVERING BEETS TO THE FACTORY.

After they are harvested and thrown in piles in the field the beets are usually loaded into wagons and hauled directly to the factory or to a railway station for shipment to the factory. Ordinary farm wagons are often used for this purpose; but wagons specially designed for this work are more satisfactory, and hence are widely used. The bottom and sides of the wagon bed are made of slats with one-half to 1 inch spaces between. As the beets are hauled the shaking and rubbing of the beets tends to free them of adhering soil, which falls out through the cracks. The ends of the wagon bed are stationary and the sides are hinged so as to drop down. These wagons will hold from 3 to 6 tons. A net of rope having from 2 to 3 inch mesh is spread in the wagon first, and on this the beets are thrown. On arrival at the factory the side next the bin is lowered and the projecting net on the other side is fastened to a tackle and raised by power. In this way the load is dumped quickly and with little labor. Sometimes nets are used as a means of lifting beets from ordinary farm wagons.

Where the beets are shipped by rail a special dumping apparatus is installed at the shipping point. The usual form of railroad dump is a high platform approached by a long incline. The loaded wagon is drawn up, the team is unhitched, the wagon locked on the platform, the side dropped, and the platform tipped by machinery. In this way the load is dumped. With another style of dump the wagon is not driven up on a platform, but is left on the ground, the wagon bed being lifted to a height and then dumped.

In cases where there is no railroad dump, a car is placed on a siding and the beets are shoveled into it.

When delivering to the factory, the farmer need not go home with an empty wagon; he can collect manure to be used in fertilizing his fields or can obtain a load of pulp for feed. Most factories, in their contracts with farmers, stipulate that a certain percentage of the weight of the beets delivered can be taken back in the form of pulp. This is a valuable cattle food and the farmer should not miss the opportunity to use it.

TARING.

In shoveling the beets into wagons for delivery to the factory, a certain amount of extraneous matter, such as stems, tops, and clods of dirt, are also thrown in; moreover, certain soils cling to the beets more than others, especially after wet weather. Some deduction must be made from the weight of the load delivered to account for this. Again, the topping may be very poor, not enough being removed, so that there is a loss to the factory, which should be considered. A sample is taken when the load is dumped into the bins

at the factory, the actual percentage of tare is determined, and this figure is applied to the whole load. From the nature of the case, different loads may have a varying percentage of tare, and this point is a constant source of friction between the growers of beets and the factory. But usually it is stipulated in the contract made by the factory with the farmers that the latter may appoint a man to oversee this step in the process.

SILOING SUGAR BEETS.

When beets are to be preserved for manufacture during the winter months or for the production of seed, they must be carefully protected from the deteriorating effect of freezing and thawing. The simplest and the easiest method is to place them in piles and cover them with earth, not too deeply, for if they become too warm in the silo they rapidly lose in sugar content. When first siloed, they should be covered with only a slight layer of earth; as the cold of winter becomes more intense this covering can be increased. In some localities only a slight covering of straw is necessary to protect the beets, as, for instance, in California. In other localities, such as in Michigan and Wisconsin, it is probable that the beets have to be covered to the depth of 6 inches, and even more, to protect them from frost.

It is most important not to put too many beets in one pile, certainly not over 5 tons. If, however, the silo is made in the form of a rick, no such limitation is necessary. There must be an opening in the top to allow ventilation. In case of a rick there may be several. The silo should be placed on the highest point of land available to provide for proper drainage in case of heavy rains or melting snow. The beets should be siloed on the same day that they are removed from the ground.

The object of siloing, in case of beets for seed, is to prevent them from freezing, and greater care should be used in making the silos. In the case of factory beets, the purpose of siloing is not entirely to prevent freezing, for in the frozen state the beets do not deteriorate to any extent; but it is to keep them fresh and prevent their withering or drying out. Freezing and thawing, however, must be avoided, as beets that freeze and thaw a number of times lose a greater part of their sugar by inversion and decomposition.

It is becoming customary in this country for the sugar companies to ask the farmers to silo part of their beets when the total crop can not be worked up before winter sets in. To repay the farmer for this extra handling they are given a sum varying from 20 cents to 50 cents a ton extra. A few factories situated in the cooler regions where siloing must be practiced agree to take all of the beets of the farmer before frost comes and silo them, but this is not the

general practice. In California very little siloing has to be done, and then only by using the leaves as a covering.

COST AND PROFITS OF GROWING SUGAR BEETS.

The cost of growing an acre of beets depends on so many varying factors as to render it impossible to give an estimate which is reliable for every locality. The differences in rent of land, cost of labor, methods of culture, etc., require that any estimate which may be given should be revised for almost every series of conditions. The following estimate of the cost per acre, made several years ago when wages were somewhat lower than at present, is based on a yield of 12 tons per acre, except in Utah, where the yield was placed at 15 tons.

An assumed yield per acre is requisite in estimating the cost of harvesting, etc., since a part of the cultivation and the harvesting are often contracted at a certain price per ton of beets. The figures given below are from actual averages or from estimates by experienced men.

Estimated cost per acre of sugar-beet culture.

Items.	California.	Utah.	Nebraska.	Michigan.
Clearing the land			$1.00 to $1.50	$2.25
Plowing and harrowing	$5.37	$3.50	2.50 to 3.00	
Seed and seeding	1.80	2.75	3.25 to 3.85	2.50
Bunching and thinning	14.40	4.00	7.00	7.00
Hoeing		4.00	2.00 to 4.00	4.00
Cultivating		2.00	1.50 to 1.60	1.50
Other expenses		[a] 1.50		
Harvesting and delivering	[b] 1.50	[c] 15.00	11.00 to 13.20	17.20
Total	23.07	32.75	28.25 to 34.15	34.45
Cost of siloing when necessary			2.50 to 8.00	

[a] Cost of irrigation. [b] Exclusive of delivery. [c] Based on a yield of 15 tons per acre.

In the above estimate was included the cost of the best culture, but nothing for rent of land or a reasonable application of fertilizers. It is probable that the actual cost to our farmers for the first few years of the beet industry did not exceed $25 to $35 per acre and in many instances fell below these figures.

It is reasonably certain, accidents of season aside, that a net profit of from $8 to $15 per acre may be expected from the proper culture of the sugar beet in localities near a factory when all the conditions of the best methods of culture are fulfilled.

For comparison with the above estimate there are given in the following table the actual figures submitted by a Colorado farmer, as published in The American Sugar Industry and Beet Sugar Gazette of June 20, 1907, and also those given by a Wisconsin farmer and a Washington farmer in the same journal for April, 1908.

Reported cost of sugar-beet culture in three actual cases, and the net returns.

Items.	Colorado.	Wisconsin.	Washington.
Number of acres planted	5	11	11
Plowing, harrowing, leveling	$8.75	$34.85	$24.00
Seed	$12.30	$39.00	$26.70
Drilling	$2.25	$6.40	$4.00
Thinning	$22.75	$60.00	$66.00
Hoeing	$10.25		$30.50
Cultivating and ditching	$9.00	$27.50	$17.50
Irrigating	$3.50		
Total cost	$71.05	$167.75	$168.70
Average cost per acre	$14.21	$15.25	$15.34
Cost of harvesting and delivery		$218.00	$133.15
Total average cost per acre	$27.00	$35.07	$27.44
Number of tons of beets harvested		135	115
Amount received for beets		$695.00	$607.00
Average receipts per acre		$63.18	$55.18
Net returns per acre		$28.11	$27.74

In none of these estimates have the rent of the land or interest on capital been considered. It is not wise to underestimate the actual cost of growing the beets, for this will lead the farmer to expect large profits, which often in practice give way to actual deficits.

VALUATION OF BEETS AT THE FACTORY.

In the purchase of beets for sugar making the factories offer the growers either a "flat rate" or a "sliding scale." In case the former system is adopted, the factory offers a uniform price of $4.50 or $5 per ton for all beets which reach or exceed a certain minimum standard of quality, as, for instance, a sugar content of 12 or 14 per cent with a purity of 80. In case beets which fall below this standard are offered, the factory may make a reduction in the price or refuse the beets, but no extra price is paid for beets which exceed the standard requirements. If the "sliding scale" is adopted, the factory offers a minimum price of say $4 or $4.25 for beets which reach a minimum standard of quality, as, for instance, 12 per cent of sugar with a purity of 80, and makes an extra allowance per ton of 25 to 35 cents for each per cent of sugar in excess of the established minimum. Under this system beets of extra fine quality may bring $5.50 per ton or even more. Some factories buy all their beets at a flat rate, others buy only according to a sliding scale, while many offer the farmers their choice between the two systems.

In determining the quality of the beets a sample is taken from each load delivered. The percentage of sugar is determined either directly from the beet or from the expressed juice. If from the juice (which is the usual method), the percentage of sugar in the beet is calculated from that in the juice.

According to a United States Census report on the manufacture of beet sugar in 1905, the average prices paid for beets were as follows:

Prices per ton paid for beets in 1900 and 1905 compared.

State.	1905.	1900.
	Dollars.	*Dollars.*
Colorado	5.28	.....
Michigan	5.52	4.38
California	4.72	4.47
Wisconsin	5.36	.....
All other States	5.19	4.26
Average for the United States	5.22	4.39

A comparison of these figures shows that there was a large increase in the price of beets during this five-year period.

BEET-SEED PROBLEMS.

PRODUCTION OF SEED.

The production of seed is one of the most important operations connected with the sugar-beet industry. On the care and skill which are displayed in this process depend the improvement and maintenance of the sugar-producing qualities of the beet. It is, however, an industry in itself and only the result is of practical interest to the average farmer. There are many different methods employed for producing seed which will grow the richest sugar beets, but there will be given here only a general outline of the principles which underlie the process. The beets which are to be preserved for seed are called "mothers" and are selected at the time of harvesting from specially grown beets or from fields of beets which have shown particularly good qualities on analysis. The size of the roots selected for mothers is about the average for the best sugar beets, viz, from 20 to 24 ounces. Smaller beets than these might show a higher content of sugar, but it is not wise to produce a race of small beets. The weight of the mothers having been decided upon, the beets are next selected for their shape and external appearance. Those regular in shape and smooth in external form are to be preferred.

The beets to be preserved for mothers are harvested with the greatest care to avoid injury. The top is not cut away, but the leaves are removed by cutting off the stems without injuring the top of the beet.

They should be siloed in such a way as to protect the beets entirely from frost and yet prevent their growth in the silo until the spring. The beets are removed from the silo at an early date in the spring and are immediately subjected to analysis. The final selection depends upon actually determining the density of the juice and its content of sugar. For this purpose a cylindrical piece of the beet is removed

by an appropriate instrument cutting diagonally through the center of the root. This piece may weigh one-half ounce or even more, and its removal does not injure the beet for seed-bearing purposes. The juice is expressed from this piece and its specific gravity determined, as well as the percentage of sugar in the juice. From the specific gravity the amount of solid matter in the juice can be calculated. The percentage of sugar is determined by means of the polariscope.

From these data the quality of the beet is ascertained and the question as to its use as a mother for seed is determined. An important figure in this work is the ratio of sugar to total solids in the beet; that is, the sugar divided by the total solids, the quotient being multiplied by 100. This figure is spoken of as the "coefficient of purity."

The procedure for selecting beets where seed is produced on a commercial scale is in brief as follows: A standard is set for sugar content and also for purity. The beets are analyzed separately and are divided into two classes, namely, those in which either the content of sugar or the purity falls below the fixed figure, and, second, those in which these two numbers equal or exceed the fixed figures. It is sometimes customary to divide the latter class into two portions, viz, those roots in which the numbers equal or slightly exceed the standard, and, second, those which show exceptional richness. It is also customary to number each beet, and the number, which is cut into the skin of the beet, will remain legible even after the seed has ripened. Some of the producers of sugar-beet seed preserve the product of seed from each beet by itself, and do not use it to inaugurate the production of seed for commerce until it has received an additional year's trial.

Many seed producers determine the percentage of sugar in the beet by a direct analysis of a pulped sample and base the selection of the mothers on the number so obtained, without regard to the coefficient of purity, as it has been proven in Germany that a beet of a certain sugar content will under most circumstances have a certain purity.

By careful selection of mother beets and scientific culture the sugar beet has been raised to its present high standard of excellence, and is only maintained at this standard by constant supervision, such as has been indicated.

DOMESTIC PRODUCTION OF BEET SEED.

The commercial production of beet seed of pure pedigree and high grade has not been practiced to any great extent in this country. Beet seed has been grown for a number of years in the State of Washington and also in Utah. The latter State consumes its own crop, while the seed from Washington has been used in all the beet-growing States. In 1904 the Department of Agriculture distributed 13,962 pounds of American-grown sugar-beet seed, the greater part coming

from Washington. This seed went to farmers growing beets for factories, and therefore was tested in direct comparison with the factory seed which is practically always imported. It was tested on 153 farms, representing thirteen different States, 564 acres being planted. The results gave an average yield for Washington-grown seed of 10.72 tons per acre, against 9.92 tons harvested from an equal area raised from imported seed.

To grow sugar-beet seed commercially certain conditions must exist which are not always applicable to experimental work. It is necessary not only that seed of high quality be grown, but also that it be grown economically and that there be reasonable certainty of a crop. Climatic conditions, such as the probability of severe rainfall at the time of harvesting, play an important part in selecting a location for a beet-seed farm. The prevalence of insects and other pests must also be considered.

COMPARATIVE VALUE OF DOMESTIC AND FOREIGN SEED.

Numerous comparisons of home-grown and imported beet seed have been made. The plants from the native-grown seed seem to have a higher vitality and to be better suited to the climatic conditions of the locality than those grown from imported seeds. They show during the growing season a more abundant foliage and a better development of roots. This higher vitality and quality of the beets grown from domestic seed illustrate in a forcible degree the advisability of the production of our beet seed at home. Even granting that seeds produced in foreign countries have the same high qualities, it must be admitted that their vitality is in danger of being very much diminished during shipment to this country. The moist air in the holds of ships in which they are transported often produces moldiness and incipient germination, which tend to diminish their value greatly. In 1904 American-grown seed yielded 10.72 tons of beets per acre with a sugar content of 15.41 per cent, while imported seed averaged 9.92 tons with 15.26 per cent of sugar, the excess of sugar from the use of American-grown seed being from 300 to 350 pounds per acre. In 1905 American-grown seed yielded 14.32 tons of beets per acre with 14.9 per cent of sugar, while imported seed averaged 12.14 tons with 15.1 per cent of sugar, an excess of more than 600 pounds of sugar per acre of beets. In 1905 the averages were taken from 278 acres. These data should be carefully studied by all those who are interested in the production of beet sugar in this country. At present there is one grower of beet seed on a large commercial scale, and it is certain that it will not be long before there will be a demand for the establishment in this country of more plantations devoted exclusively to the production of beet seed on the most approved scientific principles.

The quantity of seed required to plant an acre is about 15 pounds. The approximate number of acres planted to beets in this country during the season of 1907 was 400,000, requiring 6,000,000 pounds of seed. More than 6,500,000 pounds of seed were required for the crop of 1908. It is evident that there is already an opportunity for the active operation of large plantations devoted exclusively to the production of beet seed for domestic use.

Another point to be considered is that by the importation of foreign seeds there is danger of introducing those diseases of beets which have occasioned such ravages in Europe.

SINGLE-GERM BEET SEED.

The average beet-seed ball contains from 1 to 7 germs or seeds, each capable under certain conditions of producing a plant. In practice some seed balls will produce as high as seven plants, while others will only produce one. The Bureau of Plant Industry of the Department of Agriculture has undertaken the development of a strain of sugar beets bearing single-germ seed balls, and the results of that work up to 1905 have been published in a bulletin of that Bureau (No. 73). By careful selection, plants bearing 50 per cent of single-germ seeds have been produced. It is confidently expected that in time a plant bearing only single-germ seeds will be produced. The economy in the use of such seed is evident, as, when planted in a row, the thinning can be done by means of a hoe, thus doing away with hand thinning. This work was undertaken in 1902, and up to the present time is still in an experimental stage, none of this seed being available for distribution.

DISEASES AND INSECTS AFFECTING THE SUGAR BEET.

There are three diseases of the beet which prove especially destructive: One is the "leaf spot" due to a fungus (*Cercospora beticola*), in which the leaves are covered with brown spots and die, forcing the beet to throw out new leaves at the expense of the sugar content and growth of the root. This has been successfully combated on a small scale by spraying with Bordeaux mixture, but whether this can be done economically on a commercial scale is still under investigation. The second disease, "root rot," likewise due to a fungus (Rhizoctonia), in which the roots finally rot off, seems to be increasing. If attended to in time, it can be checked by the use of air-slaked lime. The lime is sprinkled broadcast over the infected area and thoroughly hoed into the soil. The third disease, known as "curly top," causes the leaves to curl up; the beet does not develop, but finally dies. No satisfactory means of combating this disease has

so far been devised, but a report on the subject has been issued by the Bureau of Plant Industry[a] of the Department of Agriculture.

A number of other diseases, including "crown rot" and "damping off," have been studied, but they are confined to small particular areas and have not wrought the damage that follows the three especially mentioned.

Many species of insects use beets as food. Not more than about 50 species, however, are classed as noticeably destructive to the crop. Many of these have received extended notice in publications of the Bureau of Entomology[b] of the Department of Agriculture. From these reports the farmer can learn what has been done along this line and obtain suggestions as to the means of fighting the pests.

The beet growers should send specimens of insects injurious to their crops direct to the Bureau of Entomology for specific identification and advice as to remedies.

THE MANUFACTURE OF SUGAR.

THE FACTORY PROCESS.

The process of making sugar from the sugar beet is only of secondary interest to the farmer, and will be treated as briefly as possible, giving merely an intelligent general idea of the methods followed. The beets are stored in bins which narrow down to a flume covered by small boards. By removing the boards, one at a time, the beets are fed into the flume, where a swift running stream of water carries them to a wheel or screw that lifts them to a washing tank. This is provided with an apparatus for keeping the beets in motion and transferring them toward the end from which the fresh water enters. In this process the whole of the adhering soil, together with any sand and pebbles, is completely removed. By a suitable elevator the beets are next taken to a point above the diffusion battery, where they pass into automatic scales, which dump them when a certain weight has been received. From this they are dropped into a slicing apparatus, by which they are cut into thin pieces, called "cossettes," of greater or less length, and of such a shape that when placed in the cells of the battery they will not lie so closely together as to prevent the circulation of the diffusion liquors. When the cell is full of the sliced beets it is closed and the hot juices from the cell last filled are admitted and allowed to remain in contact with the cuttings for a few minutes. From 10 to 12 cells are thus kept in use. While one is filling another is emptying. The fresh hot water is

[a] U. S. Dept. Agr., Bureau of Plant Industry, Bul. 122.

[b] A Brief Account of the Principal Insect Enemies of the Sugar Beet, Bul. 43, Bur. of Ent., U. S. Dept. of Agr. Reference is also made to insects of this class in Buls. 23, 29, 33, 54, and 66 of the same series.

always admitted to the cell next to be emptied and passes in succession through all the cells under pressure, until it reaches the one last filled. From this cell a quantity of juice is drawn off each time and sent to the carbonatation tanks for purification. With the drawing

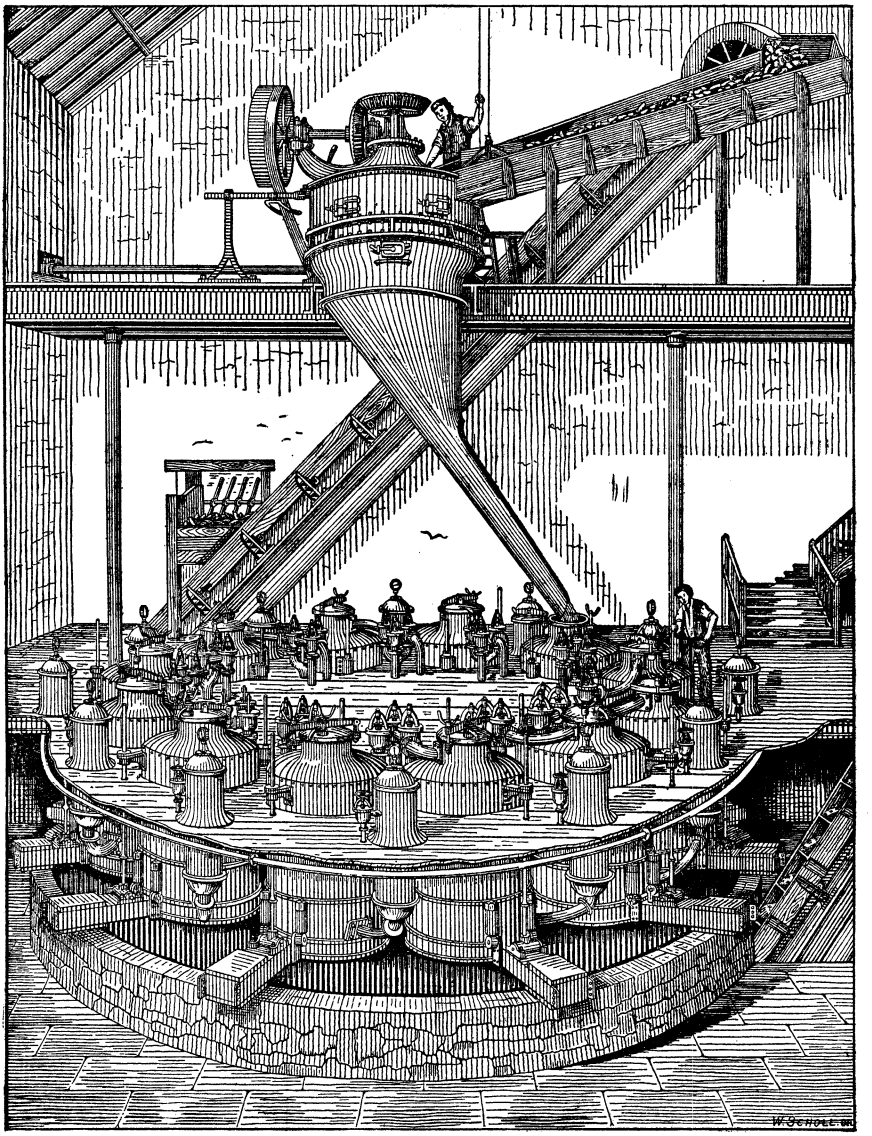

FIG. 15.—Diffusion battery.

off of a certain quantity of the juice, one cell of exhausted beet pulp, the last one in the circuit, is dumped. Figure 15 illustrates in a general way the arrangement of a diffusion battery, but the circular type

there shown is no longer in use, the cells now being arranged in a straight line.

The extracted cuttings are carried by conveyers to a press, where a portion of the water is removed, and they are then "scrolled" out to a silo in suitable condition for use as cattle food. The diffusion juice obtained as above described is conveyed to carbonatation tanks, where it is treated with from 2 to 3 per cent of its weight of lime in the form of a thick milk. The whole is heated and carbonic acid gas (obtained from the limekiln) is pumped into the mixture until a certain alkalinity of the juice is obtained. By this process the impurities in the diffusion juice are to a great extent thrown out and some of the extra lime precipitated also.

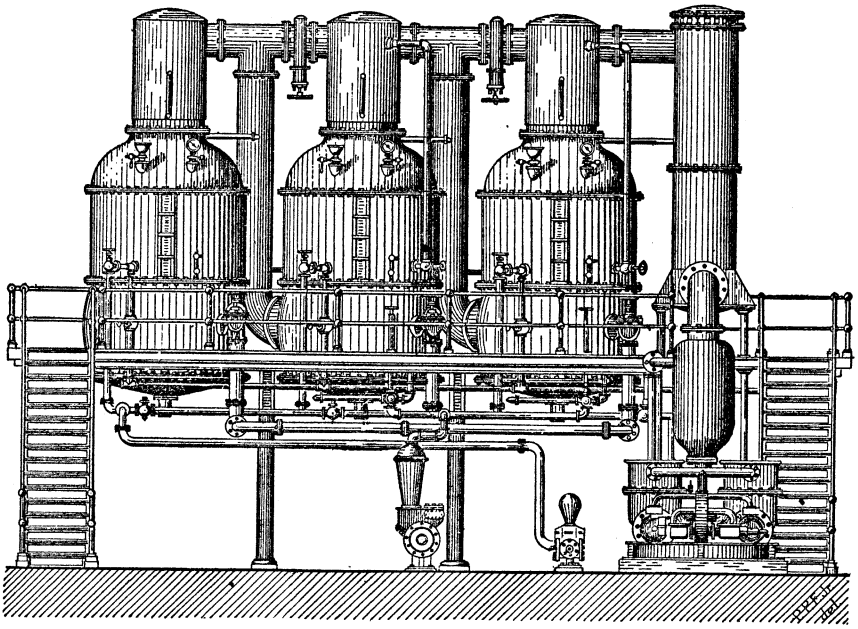

FIG. 16.—Multiple-effect evaporating apparatus.

The slightly alkaline juice is next passed through filter presses, by which the precipitated lime and other solid matters are removed. The juice from these filters then passes to a second set of carbonatation tanks, in which they undergo a treatment similar to that just mentioned, but the quantity of lime added is small as compared with that of the first carbonatation. The refiltered juices from the second carbonatation, usually termed the "saturation," are then sent to tanks, through which the fumes of burning sulphur or sulphur dioxid are passed. This treatment removes more lime and impurities besides lightening the color of the juice. From these tanks the juice goes to another set of filters, generally composed of bags, and from there to storage tanks for the multiple-effect evaporators.

The multiple-effect evaporating apparatus (fig. 16) consists of a series of pans connected in such a manner as to secure a progressively higher vacuum. The thin juices enter the first pan, where they may be evaporated, either under slight pressure or in a vacuum. The steam with which this evaporation is effected is usually the waste coming from the engines and pumps of the factory.

The vapors generated in the first pan enter the heating pipes of the second one, and are thus utilized in evaporating the somewhat concentrated sirup which is drawn off from the first pan into the second one, where the vacuum is higher, being represented by a column of mercury of from 12 to 15 inches in height. The vapors which are produced in

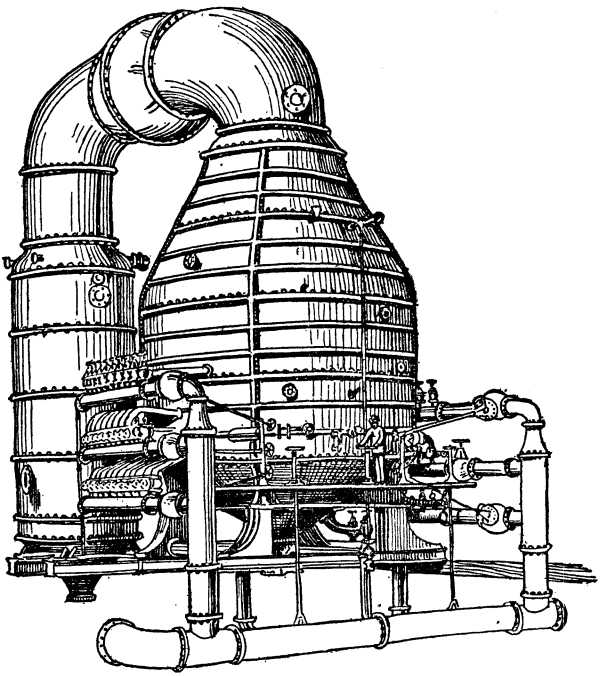

FIG. 17.—Vacuum strike pan.

the second pan are in like manner conveyed to the heating pipes of a third apparatus, where the still more concentrated sirups from the second pan are conducted and evaporated at the highest vacuum obtainable in such apparatus, usually from 26 to 28 inches of mercury. Usually a fourth pan is employed, but the arrangement is fully illustrated by the above example. It is easy to see by the arrangement above noted that the evaporation of the thin diffusion juices to a heavy sirup is accomplished with the greatest economy, direct steam being admitted only into the first pan, and the rest of the operation being accomplished by the steam generated in the evaporation of the liquors. The thickened juice from the last effect of the multiple

evaporator is sent to tanks where it is again treated with lime, phosphoric acid, and soda to remove impurities, and also with sulphur dioxid to lighten the color. From here it passes to bag filters and then into storage tanks. This juice is converted into sugar in the following manner:

A portion of the sirup is placed in an evaporating apparatus called the strike pan. This apparatus is very large, usually a cylindrical vessel with a conical bottom, and is provided with a series of coils, one above the other, to which the steam can be admitted at will. The admission of steam is always so regulated that it is not allowed to enter any of the coils above the surface of the liquid in the pan. The

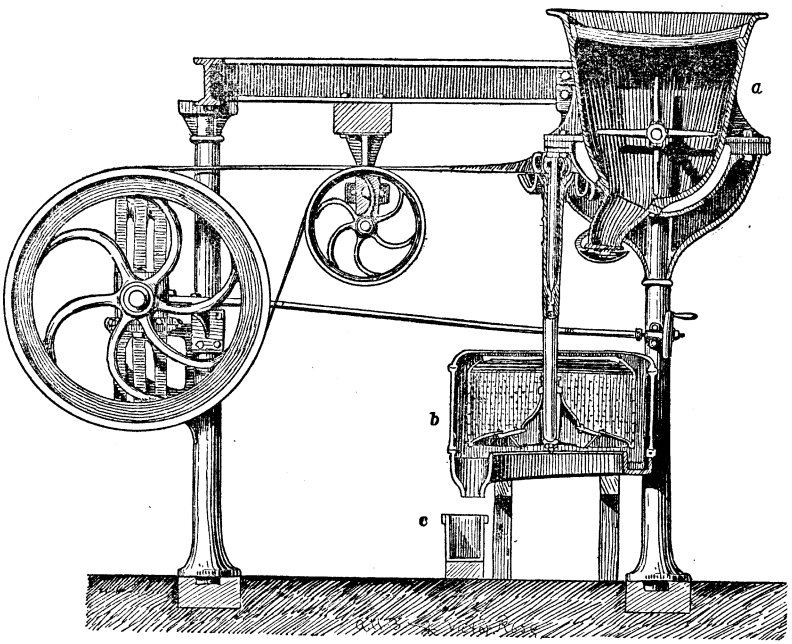

FIG. 18.—Centrifugal apparatus: *a* holder for massecuite; *b* centrifugal basket with fine wire lining *c* molasses trough.

portion of sirup first introduced is evaporated until it reaches a point of consistency which will permit of the formation of crystals, i. e., supersaturation. In this condition, if a portion of fresh sirup be introduced the whole mass in the pan becomes charged with exceedingly fine crystals of sugar.

By careful manipulation and the introduction of new quantities of sirup from time to time these crystals are made to grow. As the pan becomes full successive coils of the steam pipes are brought into use, so that the boiling surface of the pan is gradually increased in proportion to the volume of its contents. In the course of a few hours the skilled sugar boiler will find that the pan is full and that the crystals

have grown to the proper size. The charge in the vacuum pan at this stage is extremely heavy, consisting of a dense mass of sugar crystals mixed with a quantity of molasses which varies in amount with the purity of the juices from which the sugar is made. This product is termed massecuite. The illustration (fig. 17) shows the vacuum pan. In boiling sugar in a vacuum pan, if the highest possible yield is desired and no objection arises to the formation of soft crystals, a very high vacuum, equivalent to 29 inches of mercury at the sea level, is employed. At this vacuum the sirups boil at a temperature of from 112° to 120° F. If harder crystals, giving a somewhat less yield are desired, as in the case of making granulated sugars, a lower vacuum, namely, from 24 to 26 inches, is employed.

The massecuite is then dropped directly to the mixer, where it is stored for charging the centrifugals below it.

The construction of the centrifugal apparatus and mixer is shown in figure 18. The centrifugal basket is suspended and run by the spindle. The whole basket is incased in an armor-plate jacket and is lined with fine wire gauze. The charge of massecuite is let down into the basket, which is revolved by means of the belt at a speed of about 1,200 revolutions per minute. At this speed the molasses is separated from the sugar crystals, being thrown out through the holes of the screen onto the outer jacket, where it collects and finally runs through the trough, provided for the purpose, to the storage tank. The color of the charge is now changed from brown to light yellow. By a sprinkling can or a small spray of water the rest of the molasses in the fast running centrifugal is washed off of the crystals.

From the centrifugals the sugar passes by belts and conveyers to bins for storage. From these it is carefully and slowly fed into a heated revolving drum where the sugar is dried and the masses of individual crystals are broken up. This is termed granulation. From this point the sugar passes to weighing machines where it is barreled or sacked for commerce.

The resulting molasses is still rich in sugar and is brought back to the vacuum pan where it is boiled to a massecuite which is placed in large double-jacketed tanks having a revolving worm. The double jacket is filled with heated water and the massecuite is allowed to stay in the tank for a number of days, being mixed by the revolving arm. The temperature is allowed to fall slowly and by this means more crystals of sugar are formed. When no more of the sugar will crystallize, the tank or "crystallizer" is emptied into another set of centrifugals and the sugar is spun off. This crop is generally very dark in color and washing does not lighten it to a white sugar. It is known

as second sugar and is melted in water and boiled up with the juice from the evaporator in the vacuum pan to make white sugar. In its raw state it is not the same as the yellow sugar of commerce, being generally salty and disagreeable in taste. The resultant molasses is sometimes boiled for a third crop of sugar, but generally it is sent to storage or is used in the osmose or Steffens process for removing more sugar from the molasses.

In the osmose process a stream of heated, diluted molasses is run in a suitable press in the opposite direction to a stream of hot water, a sheet of parchment paper separating the two streams. By this means a greater portion of the salts passes through the membrane and enters the water which flows away. The sirup is made richer, and by boiling in the evaporator and in the pan a massecuite is formed that is stored in crystallizers, and finally the sugar is spun off. The remaining molasses is sometimes reosmosed, but generally it is sold to be mixed with pulp or grain for cattle food or is used for alcohol making.

In the Steffens process the molasses is diluted and cooled to a low temperature, which is kept constant while finely powdered fresh lime is added slowly. In this way a saccharate of lime is formed which is insoluble in the liquid, and by passing the whole material through filter presses it is separated. The cake from the presses is diluted with water and takes the place of the milk of lime used in the carbonation. When this process is employed there is no residue molasses; the only waste is the strongly alkaline water containing the salts of the molasses which have been separated from the saccharate of lime. This water is rich in potash salts and could be used as a fertilizer.

The beet-sugar factories of this country sell only the white granulated sugar; none of them produce raw sugar and turn it over to the refineries to be passed over bone black and made into white sugar, as is the custom in Europe.

COST OF MANUFACTURE.

The cost of manufacture depends on as many factors as that of beet growing. Chief among these are transportation, fuel, weather, and labor. Perhaps the most important of these factors is the price of fuel. In some localities coal can be had for $1.25 per ton; in others the cost may reach as high as $10 per ton.

The manufacture of beet sugar is conducted without governmental supervision in this country, and any exact account of its cost is inaccessible. To show what it may be, when a wide experience and the best management are brought to bear upon the work, the mean cost of manufacture in 113 German factories is given.

Mean capital invested in each factory		$193,400.00
Total receipts for sugar, molasses, and pulp per ton of beets		11.10
Mean cost of beets per ton of 2,204.62 pounds	$4.90	
Salaries per ton of beets	.26	
Labor per ton of beets	.73	
Interest on investment per ton of beets	.36	
Coal per ton of beets	.63	
Miscellaneous expenses per ton of beets	.96	
Total expense of manufacture per ton		7.84
Profit per ton of beets		3.26

The mean net profit for each factory was $34,240. The price paid for beets, however, is in most cases fictitious, the beet growers owning the factory and preferring to share in the general profits rather than to charge a high price for the beets. First-class beets rarely sell for less than $5 per ton. The Western Beet Sugar Company, of Watsonville, Cal., stated that in its first campaign, 1888–89, the cost of manufacture amounted to $80.80 per ton of sugar. At the present time it appears that with the best machinery, rich beets, and most economical processes beet sugar can be made in this country at a cost of less than 4 cents per pound, even when the price of rich beets exceeds $5 a ton.

COST AND CAPACITY OF FACTORIES.

The cost of building a first-class beet-sugar factory is much greater than is commonly supposed. Roughly speaking, for every ton of daily capacity, the plant costs $1,000; that is, a 500-ton plant would cost $500,000 and a 1,000-ton factory would cost $1,000,000. It has been demonstrated in the United States that a beet-sugar mill, in order to work economically, must have a capacity to work 500 tons of beets daily, and that one having a capacity of much more than 1,200 or 1,500 tons a day is unwieldy. The largest factory in the United States can handle 3,000 tons a day. In Germany there are a few small factories of 200 and 300 tons capacity, but the tendency of late has been to increase the size. In the early days of the beet-sugar industry in this country, Europe was called on to furnish all machinery. Now, very little is imported, and, in fact, some of the foreign factories are using American-made machinery.

COOPERATIVE FACTORIES.

It is seen from the foregoing paragraph that the farmer can have no reasonable hope of successfully establishing a home beet-sugar factory. It is not just, however, that he should be deprived of any cooperation in the process of manufacture or a reasonable share of the profits arising therefrom. The methods which have been practiced in Europe for securing these results may eventually come into use in this country. The cooperative sugar factory, in which the farmers growing the

beets hold a part or a majority of the stock, realizes the desired end. The growers of beets holding shares in the factory have a greater interest in its prosperity and try to grow better crops and to secure in every way a higher yield. The cooperative factory renders impossible those disagreements between factory and agriculture which do so much to retard the progress of the industry and to embitter the farmers against the factory. To show the extent of the participation of shareholders in factories in the growing of beets in Germany, it may be stated that of the 11,672,816 metric tons of beets delivered to the German factories in 1895–96, 2,689,004 tons were grown by shareholders. As long as the proprietors of the factory and the farmers growing the beets are satisfied with the contracts which they make, there is no urgent necessity for the establishment of cooperative enterprises. When the number of beet-sugar factories in this country, however, begins to reach the hundreds, favorable opportunities for cooperative establishments will be presented.

USES OF BY-PRODUCTS.

The by-products from beet culture on the farm are the tops and leaves, which are commonly used for feeding cattle. Some farmers, however, turn them under as a fertilizer. When used as a feed, the beet tops can be eaten by the cattle on the field where they have been grown. If they are fed in stalls, the manure should be returned to the field.

The by-products of the factory consist of pulp, lime cake, and molasses. The pulp is a valuable cattle food and the farmer should contract with the sugar company to obtain his share of it. It can be stored in siloes, if well drained, and be fed fresh or in a fermented condition. The value of the pulp for feeding purposes is variously estimated at from one-fifth to one-third the value of the beets. Its sugar content is not sufficient to make it of any value as a source for alcohol manufacture. Lime cake in most factories is washed out with water to the sewer. In others it is wheeled out and dumped in piles and can be used on some lands as a fertilizer, though for this purpose the demand for it is limited. Lately it has been used in cement making. Molasses has a value as a cattle food, but it must not be fed very heavily or scouring of the cattle will result. The best practice is to sprinkle it on the hay, alfalfa, or roughage. Some factories mix the molasses with the pulp and dry the whole, either pressing it into bricks or selling it loose. With the increased installation of the Steffens process of desugarizing molasses, there is not so much molasses resulting from beet-sugar manufacture as was obtained a few years ago. In an economical plant all molasses should go through this process and only that produced at the end of the season be saved. It is a question whether the introduction of denatured alcohol into the

arts, as well as for fuel and light, will not tend to reduce the number of Steffens plants and result in the sale of the molasses for distillation. Beet molasses contains about 50 per cent of sugars capable of fermentation. One gallon weighing about 12 pounds contains approximately 6 pounds of sugar, which will produce about 3 pints of 95 per cent alcohol. In other words, for every 2½ gallons of molasses 1 gallon of alcohol can be made.

STATISTICS OF PRODUCTION AND CONSUMPTION OF SUGAR.

In the data giving the production and consumption of sugar the unit of value commonly employed is the ton. By reason of the fact that the ton in this country expresses a unit of varying magnitude a considerable degree of confusion is often introduced into statistical tables. In the following tables the kind of ton used is specified in each case. The long ton, which is often used in compiling sugar statistics, contains 2,240 pounds. The short ton, namely, 2,000 pounds, is a more convenient unit of expression, and is largely used in the publication of sugar statistical data in this country. The metric ton, which is used on the continent of Europe, is a weight of 1,000 kilograms, equivalent to 2,204.62 pounds.

BEET-SUGAR PLANTS IN THE UNITED STATES.[a]

The following table gives a complete list of beet-sugar plants in the United States, arranged by States, showing the official names of the manufacturing companies and the locations of the factories. It also shows the daily slicing capacity, expressed in tons of beets, for each factory, the combined daily slicing capacity of the factories in each State, and the aggregate capacity of all the factories in the United States.

Beet-sugar companies and factories of the United States.

Manufacturing companies.	Factory locations.	Number of factories.	Daily slicing capacity.
			Tons of beets.
California:			
Alameda Sugar Co	Alvarado		800
Los Alamitos Sugar Co	Los Alamitos		700
Spreckels Sugar Co	Spreckels		3,000
Union Sugar Co	Betteravia		600
American Beet Sugar Co., main office, 32 Nassau street, New York; Pacific coast office, 604 Mission street, San Francisco.	Chino		900
	Oxnard		2,000
Pacific Sugar Corporation, Los Angeles, Cal	Visalia		400
Pacific Sugar Construction Co	Hamilton City		700
Total		8	9,100
Colorado:			
American Beet Sugar Co., 1530 Sixteenth street, Denver, Colo.	Rocky Ford		1,100
	Lamar		600
	Las Animas		700
Holly Sugar Co	Holly		600
Holly Construction Co	Swink		1,200
National Sugar Manufacturing Co	Sugar City		500

[a] From Progress of the Beet-Sugar Industry in the United States, 1907. Report 86, U. S. Dept. of Agr.

Beet-sugar companies and factories of the United States—Continued.

Manufacturing companies.	Factory locations.	Number of factories.	Daily slicing capacity.
			Tons of beets.
Colorado—Continued.			
	Eaton		600
	Greeley		600
	Loveland		1,200
	New Windsor		600
The Great Western Sugar Co., general offices, Sugar Building, Denver, Colo.	Longmont		1,200
	Fort Collins		1,200
	Sterling		600
	Brush		600
	Fort Morgan		600
The Western Sugar and Land Co	Grand Junction		600
Total		16	12,500
Idaho:			
	Idaho Falls		1,200
Utah-Idaho Sugar Co., main office, Salt Lake City, Utah.	Sugar		1,200
	Blackfoot		600
	Nampa		750
Total		4	3,750
Illinois:			
Chas. Pope, Chicago, Ill	Riverdale	1	350
Iowa:			
Iowa Sugar Co	Waverly	1	500
Kansas:			
United States Sugar and Land Co	Garden City	1	850
Michigan:			
	Bay City		600
	Caro		1,200
Michigan Sugar Co., general offices, Saginaw, Mich.	Alma		700
	Carrollton		850
	Sebewaing		600
	Croswell		600
West Bay City Sugar Co	Bay City, West Side		600
Holland Sugar Co	Holland		300
Owosso Sugar Co., main office, Bay City, Mich	Owosso		1,250
	Lansing		600
German-American Sugar Co	Bay City, Station A		650
Mt. Clemens Sugar Co	Mt. Clemens		600
Menominee River Sugar Co	Menominee		1,200
St. Louis Sugar Co	St. Louis		600
The Continental Sugar Co., main office, Cleveland, Ohio.	Blissfield		600
West Michigan Sugar Co	Charlevoix		600
Total		16	11,550
Minnesota:			
Carver County Sugar Co	Chaska	1	600
Montana:			
The Great Western Sugar Co	Billings	1	1,200
Nebraska:			
American Beet Sugar Co	Grand Island	1	350
New York:			
Lyons Beet Sugar Refining Co	Lyons	1	600
Ohio:			
Continental Sugar Co	Fremont	1	400
Oregon:			
Amalgamated Sugar Co	La Grande	1	400
Utah:			
Amalgamated Sugar Co., office, Ogden, Utah	Logan		600
	Ogden		400
Lewiston Sugar Co	Lewiston		600
Utah-Idaho Sugar Co., main office, Salt Lake City, Utah.	Lehi[a]		1,200
	Garland		1,200
Total		5	4,000
Washington:			
Washington State Sugar Co., main office, Spokane, Wash.	Waverly	1	500
Wisconsin:			
Wisconsin Sugar Co., main office, Milwaukee, Wis.	Menomonee Falls		500
Chippewa Sugar Co., main office, Milwaukee, Wis.	Chippewa Falls		600
Rock County Sugar Co	Janesville		600
United States Sugar Co	Madison		600
Total		4	2,300
Grand total		63	48,950

[a] Slicing stations at Springville, Spanish Fork, and Provo.

BEET-SUGAR PRODUCTION IN THE UNITED STATES, 1830-1907.

The following table shows the production of beet sugar in the United States from the beginning of the industry to the close of the season of 1907. The data for 1897 and for 1901–1907 are from reports published by the United States Department of Agriculture on Progress of the Beet-Sugar Industry in the United States. Figures for other years are from Willett & Gray. (See Yearbook, U. S. Department of Agriculture, 1907, pp. 687, 688.)

Beet sugar produced in the United States, 1830–1907.[a]

1830	A few hundred pounds	1890	3,459 tons
1831–1837	None	1891	5,356 tons
1838–39	1,300 pounds	1892	12,018 tons
1839–1862	None	1893	19,950 tons
1863–1871	300 to 500 tons per annum	1894	20,092 tons
1872	500 tons	1895	29,220 tons
1873	700 tons	1896	37,536 tons
1874–1877	Under 100 tons per annum	1897	40,398 tons
1878	200 tons	1898	32,471 tons
1879	1,200 tons	1899	72,944 tons
1880	500 tons	1900	76,859 tons
1881–82	Less than 500 tons	1901	164,827 tons
1883	535 tons	1902	194,782 tons
1884	953 tons	1903	214,825 tons
1885	600 tons	1904	216,173 tons
1886	800 tons	1905	279,393 tons
1887	255 tons	1906	431,796 tons
1888	1,861 tons	1907	413,954 tons
1889	2,203 tons		

PRODUCTION OF SUGAR BEETS AND OF BEET SUGAR IN THE UNITED STATES, 1901-1907.

The following statements are taken from Report No. 86, Progress of the Beet-Sugar Industry in the United States in 1907:

The acreage planted to sugar beets in the United States in 1907, together with the percentage abandoned owing to unfavorable weather conditions, mistakes of growers, or other causes, is shown in the following table:

Acreage planted to beets in 1907.

State.	Planted.	Abandoned.	State.	Planted.	Abandoned.
	Acres.	*Per ct.*		*Acres.*	*Per ct.*
California	52,823	10.3	Wisconsin	13,800	14.2
Colorado	134,848	5.3	Ten other States	45,197	9.0
Idaho	29,051	10.7			
Michigan	95,302	7.3	The United States	400,953	7.5
Utah	29,932	4.2			

[a] In long tons of 2,240 pounds.

Comparison with the acreage harvested shows that about 30,000 acres, or 7½ per cent, of the acreage planted was abandoned. Comparison with the figures for the preceding year shows that the acreage planted exceeds that for 1906 by 3,338 acres, while the acreage harvested is about 5,000 less, the acreage abandoned in 1906 being only 5.2 per cent. The increased loss of acreage was due mainly to unfavorable spring weather, particularly in Wisconsin, Nebraska, Idaho, and California.

General factory and farm results.

BY STATES, FOR 1907.

State.	Factories in operation.	Area harvested.	Average yield of beets, per acre.	Beets worked.	Sugar manufactured.		Estimated average extraction of sugar.	Average sugar in beets.	Average purity coefficient of beets.	Average length of campaign.
					Pounds.	Tons.[a]				
		Acres.	*Tons.*[a]	*Tons.*[a]			*P. ct.*	*P. ct.*		*Days.*
California	8	47,387	10.23	484,816	146,045,500	73,023	15.06	17.9	85.1	73
Colorado	16	127,678	11.93	1,523,303	338,573,000	169,286	11.11	15.3	81.5	127
Idaho	4	25,938	9.41	244,080	75,928,200	37,964	15.55	17.8	88.3	88
Michigan	16	88,334	7.89	696,785	169,452,000	•84,726	12.16	15.1	84.7	70
Utah	5	28,663	12.32	353,159	88,973,500	44,487	12.60	16.3	86.0	116
Wisconsin	4	11,837	10.37	122,800	30,320,000	15,160	12.35	15.1	85.6	61
States having but a single factory[b]: Illinois, Iowa, Kansas, Minnesota, Montana, Nebraska, New York, Ohio, Oregon, Washington	10	41,147	8.33	342,928	77,964,230	38,982	11.37	15.1	82.3	70
Totals and averages.[c]	63	370,984	10.16	3,767,871	927,256,430	463,628	12.30	15.8	83.6	89

TOTALS AND AVERAGES, BY YEARS, 1901–1906.[d]

		Acres.	*Tons.*[a]	*Tons.*[a]	*Pounds.*	*Tons.*[a]	*P. ct.*	*P. ct.*		*Days.*
1906	63	376,074	11.26	4,236,112	967,224,000	483,612	11.42	14.9	82.2	105
1905	52	307,364	8.67	2,665,913	625,841,228	312,921	11.74	15.3	83.0	77
1904	48	197,784	10.47	2,071,539	484,226,430	242,113	11.69	15.3	83.1	78
1903	49	242,576	8.56	2,076,494	481,209,087	240,604	11.59	[e]15.1	(*f*)	75
1902	46	[g]216,400	8.76	1,895,812	436,811,685	218,406	11.52	[e]14.6	[e]83.3	94
1901	36	175,083	9.63	1,685,689	369,211,733	184,606	10.95	14.8	82.2	88
Averages 1901–1906	.....	252,547	9.66	2,438,593	560,754,027	280,377	11.50	15.0	82.8	86

[a] Tons of 2,000 pounds each.
[b] Grouped together to avoid giving publicity to the data of individual factories.
[c] The average yield of beets per acre is found by dividing the total beets worked by the total acreage harvested; the average extraction by dividing total sugar produced by total beets worked; the average contents of sugar, coefficients of purity, and length of campaigns by adding the figures reported by the different factories and dividing by the number of factories reporting.
[d] Compiled from the annual reports on Progress of the Beet-Sugar Industry in the United States.
[e] These averages are not based on data for all the factories, as some of them failed to report results of tests, but it is believed that they fairly represent the average character of the total beet crops.
[f] No data reported.
[g] Based on reports from 27 factories and careful estimates for 15 others.

CONSUMPTION OF SUGAR IN THE UNITED STATES.

The following table shows the quantities of imported sugar (both cane and beet) consumed in this country during the past three years, the quantity of domestic cane, beet, and maple sugars, and the quantities of sugar made in this country from imported molasses. Of the total quantity consumed in 1907, nearly 80 per cent was imported either from foreign countries or the insular possessions of the United States, while less than 13 per cent was domestic beet sugar. The total annual consumption has nearly reached 3 million tons of 2,240 pounds.

Consumption of sugar in the United States, 1905–1907.

[According to Willett & Gray, January 9, 1908.]

Kind and origin.	1907.	1906.	1905.
	Tons.[a]	*Tons.*[a]	*Tons.*[a]
Cane and beet sugar from foreign countries and insular possessions	2,337,352	2,281,599	2,056,092
Cane sugar, Louisiana and Texas	264,968	267,947	334,522
Beet sugar, United States	375,410	300,317	220,722
Maple sugar	10,000	6,000	9,000
Molasses sugar, made in United States from foreign molasses	6,249	8,150	11,880
Total domestic sugar	656,627	582,414	576,124
Total consumption of all sugars	2,993,979	2,864,013	2,632,216

[a] Tons of 2,240 pounds.

The total annual consumption of sugar in the United States, the percentage of increase or decrease year after year, and the per capita consumption for the years 1884–1907 are shown in the table which follows. The total consumption has increased nearly 140 per cent, while the per capita consumption has increased over 52 per cent since 1884.

Consumption of sugar in the United States for twenty-four years, 1884–1907.

[According to Willett & Gray.]

Year.	Total amount sugar consumed.	Increase (+) or decrease (−).[a]	Consumption per capita.	Year.	Total amount sugar consumed.	Increase (+) or decrease (−).[a]	Consumption per capita.
	Tons.[b]	*Per cent.*	*Pounds.*		*Tons.*[b]	*Per cent.*	*Pounds.*
1884	1,252,366	+ 7.01	51.00	1896	1,940,086	−0.49	60.90
1885	1,254,116	+ 0.14	49.95	1897	2,070,978	+6.75	63.50
1886	1,355,809	+ 8.11	52.55	1898	2,002,902	−3.29	60.30
1887	1,392,909	+ 2.74	53.11	1899	2,078,068	+3.75	61.00
1888	1,457,264	+ 4.62	54.23	1900	2,219,847	+6.83	66.60
1889	1,439,701	− 1.21	52.64	1901	2,372,316	+6.87	69.70
1890	1,522,731	+ 5.77	54.56	1902	2,566,108	+8.17	72.80
1891	1,872,400	+22.96	67.46	1903	2,549,642	−0.64	70.90
1892	1,853,370	− 1.02	63.76	1904	2,767,162	+8.53	75.30
1893	1,905,862	+ 2.83	63.83	1905	2,632,216	−4.88	70.50
1894	2,012,714	+ 5.55	66.64	1906	2,864,013	+8.81	76.10
1895	1,949,744	− 3.13	64.23	1907	2,993,979	+4.54	77.54

[a] As compared with the preceding year. [b] Tons of 2,240 pounds.

Although in recent years the beet-sugar industry has made great strides in the United States, and there has been some growth of the cane-sugar industry, the increase in production has not by any means kept pace with the increase in consumption. In fact, much more foreign sugar is consumed now than was the case ten years ago. In 1897 our total consumption of sugar was 2,070,978 long tons; in 1907 it was 2,993,979 tons, an increase in ten years of 923,000 tons. During the same period the increase in domestic production has been only about 350,000 tons.

SUGAR IMPORTED FOR CONSUMPTION.

The next table shows the character of the sugar imported for consumption, and its origin. Nearly 85 per cent of the sugar imported comes from Hawaii, Porto Rico, the Philippines, and Cuba under tariff concessions, while only about 15 per cent comes from other countries and pays full duty. The imports from both Porto Rico and Cuba are steadily increasing, Cuba alone furnishing about 58 per cent of the foreign sugar consumed in the United States in 1907, and about 45 per cent of the total sugar consumed. It will be noticed that nearly all the imported sugar consumed in the United States is made from cane; in 1906 less than 8 per cent was from beets, and in 1907 less than 1 per cent. In fact, if the sugar made in the United States be included, it appears that only about 13 per cent of the sugar consumed in this country in 1907 was made from beets.

Consumption of imported sugar, 1905–1907.

According to Willett & Gray.

Kind and origin.	1907.	1906.	1905.
Imports on which tariff concession is allowed:[a]	*Tons.*[b]	*Tons.*[b]	*Tons.*[b]
From Hawaii, cane sugar	418,102	343,857	376,497
From Porto Rico, cane sugar	212,853	193,978	124,928
From Philippines, cane sugar	10,700	41,900	14,673
From Cuba, cane sugar	1,340,400	1,165,994	1,101,611
Total	1,982,055	1,745,729	1,617,709
Imports on which full duty is assessed:[c]			
Foreign sugar—			
Raw cane	347,509	357,057	412,560
Raw beet	6,780	175,827	22,161
Refined beet	949	2,734	1,844
Refined cane	59	252	1,818
Total	355,297	535,870	438,383

[a] Sugar from Hawaii and Porto Rico is admitted free of duty; that from the Philippines at 25 per cent below the regular rate, and that from Cuba, under the reciprocity treaty, at 20 per cent less than the regular rate.

[b] Tons of 2,240 pounds.

[c] The regular rates of duty on raw sugar vary from 95 cents to $1.75½ per hundred pounds, depending on the character of the product; the regular rate on refined sugar is $1.95 per hundred pounds.

THE WORLD'S SUGAR CROP.

The following table was prepared in the Bureau of Statistics, U. S. Department of Agriculture, and published in Progress of the Beet-Sugar Industry in the United States in 1907.

Sugar production of the world, 1903–1907.[a]

Country.	1903–4.	1904–5.	1905–6.	1906–7.	1907–8.
CANE SUGAR.					
United States:	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Louisiana and Texas	248,277	350,000	342,000	243,000	347,000
Hawaii	328,103	380,576	383,225	392,871	420,000
Porto Rico	130,000	145,000	213,000	210,000	217,000
Total United States[b]	706,380	875,576	938,225	845,871	984,000
Cuba	1,040,228	1,103,258	1,178,749	1,427,673	1,200,000
Other West Indies	268,306	244,837	302,103	279,631	291,000
Mexico	107,547	107,038	107,529	108,000	115,000
Central America	21,450	19,768	18,516	19,000	19,000
South America	601,134	590,382	700,001	610,151	586,000
Total America	2,745,045	3,000,859	3,245,183	3,290,326	3,195,000
Asia	2,876,671	3,333,672	2,926,209	3,455,446	3,481,477
Africa	355,747	251,340	317,967	349,000	270,000
Oceania	163,328	216,213	230,000	249,000	276,000
Europe	28,000	18,592	15,722	16,400	11,000
Total cane-sugar production	6,168,791	6,820,676	6,735,081	7,360,172	7,233,477
BEET SUGAR.					
United States	214,825	216,173	279,393	431,796	413,954
Canada	6,710	8,034	11,419	11,367	7,943
Total America	221,535	224,207	290,812	443,163	421,897
Europe:					
Germany	1,927,681	1,598,164	2,415,136	2,238,000	2,135,000
Austria-Hungary	1,167,959	889,373	1,569,870	1,344,000	1,460,000
France	804,308	622,422	1,089,684	756,000	725,000
Russia	1,206,907	953,626	968,000	1,470,000	1,410,000
Belgium	209,811	176,466	328,770	283,000	235,000
Netherlands	123,551	136,551	207,189	181,000	175,000
Other countries	441,116	332,098	415,000	445,000	435,000
Total Europe	5,881,333	4,708,700	6,933,649	6,717,000	6,575,000
Total beet-sugar production	6,102,868	4,932,907	7,224,461	7,160,163	6,996,897
Total cane and beet sugar production	12,271,659	11,753,583	13,959,542	14,520,335	14,230,374

[a] In long tons, of 2,240 pounds, except in the case of European beet-sugar production, which has been retained in metric tons of 2,204.622 pounds, as originally estimated by Licht; United States beet-sugar data were obtained from reports of Department of Agriculture on the Progress of the Beet-Sugar Industry in the United States; other data from official statistics of various countries, and from Willett & Gray.

[b] Not including the Philippine Islands, which are included under Asia.